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THE UNIVERSITY OF ALBERTA

AN INVESTIGATION INTO THE KNOWLEDGE OF MATHEMATICS OF ALBERTA STUDENTS, BASED ON THE GRADE NINE DEPARTMENTAL EXAMINATION WRITTEN IN JUNE, 1960

by
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A THESIS
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ABSTRACT

This study investigates the knowledge of mathematics of grade IX students in Alberta, based upon the Departmental examination paper written in June, 1960, and attempts to compare the students' achievement with the standings indicated by the letter gradings on the diplomas and statements issued by the Department of Education.

The data for the report were obtained from a sample of three hundred eighty-nine examination papers written by the students, and obtained from the Examinations Branch of the Department of Education. The results, which were classified according to the four fields of arithmetic, algebra, geometry and graphic study, were analysed for each of the five categories of students as determined by the letter gradings which they received in grade IX.

Calculations were made to establish the standings of the five categories of students, based upon the ninety-four principles which the examination paper tested. It was found that the H students scored slightly under eighty per cent in arithmetic, but over eighty per cent in each of the other areas. The A students scored under sixty-five per cent in arithmetic and geometry, and over sixty-five per cent in algebra and graphic study. The B students scored less than fifty per cent in all areas except graphic study. The C students scored less than forty per cent in all areas except graphic study, while the D students obtained less than thirty per cent in all areas, and less than twenty per cent in arithmetic, algebra and geometry.

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CHAPTER I

INTRODUCTION

I. STATEMENT OF THE PROBLEM

Each year in June the grade IX high school entrance examinations are conducted under the direction of the High School Entrance Examinations Board. These examinations serve three purposes: (1) to determine the right of the students to pass from grade IX into high school; (2) as a partial basis for awarding the High School Diploma; and (3) as a means of determining matriculation standing. Students write papers in language, literature, social studies, science, mathematics, and reading comprehension. They pass or fail on the basis of their achievement on these papers. In addition they write a test of general aptitude.

One of the major problems of the Examinations Board is that of setting standards for judging satisfactory achievement. The present practice of scaling final marks has recevied much criticism on the basis that standards have fallen in recent years. The writer is not prepared to judge the accuracy of this contention, but it must be remembered that economic pressure is forcing students to remain in high school who twenty or thirty years ago would have dropped out at the end of grade VIII and found gainful employment. The result is that students of all but the lowest levels of academic ability are writing grade IX examinations.

The Royal Commission on Education investigated the field of departmental examinations (10: 51 - 70). It found that in the years from 1906 to 1935, the marks awarded to a student depended primarily upon the difficulty of the examination. Passing marks, based on raw scores, varied considerably from year to year. Various systems of bonus marks were used to achieve a reasonable distribution of marks, but lack

of consistency in their application rendered the system unsatisfactory.

The present policy of the Department of Education is outlined as follows:

> "The grading of the pupils is based on the assumption that in a LARGE group the students from year to year are about the same in ability and achievement, that is to say, from one year to the next there is the same percentage of average, of dull and of bright pupils. It would follow that the same proportion of pupils should receive high marks each year and that the percentage of failures should not vary. The actual proportion of pupils in each category was set several years ago, and except for occasional minor changes, is used from year to year and applies to almost all of the subjects. The actual scale used in grade nine follows." (3)

Table I, below, shows the distribution of letter gradings given to grade IX pupils in Alberta. (3)

TABLE I

DISTRIBUTION OF LETTER GRADINGS
TO GRADE IX PUPILS IN ALBERTA

Letter gradings given to pupils	Percentage marks used to derive letter gradings	Percentage of total number of pupils
H	80 - 100	10
A	65 - 79	25
B	50 - 64	35
C	40 - 49	20
D	0 - 39	10

When departmental examinations are marked a raw score for each paper is established. This is later converted to a scaled score. The student with the highest raw score for the province is given a scaled score which is usually one

hundred per cent, while the student with the lowest raw score is assigned a scale score near zero. A student with an actual raw score of zero receives the same scaled score. The raw scores are arranged in rank order. The top ten per cent are equated to percentage gradings ranging from one hundred per cent down to eighty per cent by means of a linear graph. These students are given an H grading. The same method is used in equating percentage scores and gradings for other categories with the exception that the percentage scores are discontinuous from thirty-seven per cent to forty per cent and from forty-seven per cent to fifty per cent. Thus the top seventy per cent of the students writing each subject receive a grading of B or higher, while the bottom thirty per cent receive either a C or a D.

The percentage distribution of raw scores is not absolutely rigid. If, for example, the cut-off point for the top ten per cent of raw scores includes some, but not all, students with the same raw score, then all students with that raw score will receive the same percentage mark. Thus the distribution may vary by a fraction of one per cent from the figures outlined above.

While percentage scores are kept on record at the Department of Education, only letter gradings appear on the diplomas sent to the individual pupils. To the teachers receiving these pupils in grade X, the letter gradings and the percentage marks which they represent indicate only the relative position of the pupil to the entire student body of the province. A B pass mark, for instance, which is shown on the statement issued to the pupil as indicating a score of from fifty to sixty-four per cent, does not mean that the raw score was fifty to sixty-four per cent, or that the pupil knew at least one-half of the material tested on the examination paper. It seems desirable for grade X teachers to have a fairly clear picture of their pupils' ability in relation to the grade IX course, as well as their ability in relation

to other pupils in the province. The purpose of this study is to provide such an analysis.

This investigation is an attempt to determine the extent to which grade IX pupils in the Province of Alberta had acquired the understanding and application of the principles tested on the Departmental examination in mathematics written in June, 1960. This study analyses the principles which were included on the examination paper, dividing them into the four areas of arithmetic, algebra, geometry and graphic study. Comparisons are made of the relative competence of the groups H, A, B, C, and D in each of these areas.

II. LIMITATIONS OF THE STUDY

The data used in this report were obtained from a sample of grade IX examination papers selected in such a way that the percentage of papers in each group, H, A, B, C, and D, correspond with the percentages in the province as a whole. No attempt was made to classify results according to population from city, town and rural centers. Neither was an attempt made to classify results by age or sex of pupils. It was felt that, while these issues could provide the basis for an interesting and useful comparison, they are not pertinent to this study, as grade X teachers must accept all the pupils who have earned a grade IX diploma.

III. BASIC ASSUMPTIONS

For the purpose of this study it was assumed that each pupil's effort was a true indication of his knowledge of the subject matter tested. It is recognized that in some cases this may not be entirely true, for there are pupils who, because of illness or the emotional stress of writing their first Departmental examination, may not have worked to the level of their ability. But it is believed that these cases are not sufficient in number to distort the picture for the province as a whole.

It was not assumed that the raw score earned was an exact indication of the pupil's knowledge with respect to that paper. To take a specific example: Question 18 requires the pupil to multiply the reciprocal of 2y/x by the coefficient of x in the term 6xy. This question tests three things:

1) knowledge of the reciprocal of a number;
2) knowledge of the coefficient of x;
3) ability to multiply algebraic terms.

Five answers were given, one of which was correct. The pupil was given no credit if he gave a wrong answer. The writer, however, analysed all incorrect answers and all rough work to determine which, if any, of the above principles the pupil understood. In compiling the tables for this report, credit was given for knowledge of principles without regard to the values assigned by the examiners.

IV. NEED FOR THE STUDY

It is felt that the information contained in this study should be useful for teachers, principals, and counsellors.

Grade X teachers of mathematics who are aware of the specific areas of weakness of their new pupils might wish to start the school year with remedial teaching in those areas, and the assignment of supplemental exercises.

Principals, as well as teachers, have a responsibility in assisting pupils to plan their high school programs. If the grade IX attainment of certain pupils indicates that they have little chance of success in the matriculation program, they can be directed into Mathematics 11 and 21, courses which are basically arithmetic, and which have a more immediate practical value from the standpoint of business and consumer education, or into the vocational courses of Mathematics 12, 22 and 32.

In the field of counselling it is important to differentiate between the individual who is retarded in specific

areas and the one who is a slow learner generally. It seems practical to establish remedial courses for students who are especially weak in mathematics, but average, or better than average, in other subjects.

The results of this study might also assist in the development of diagnostic testing programs.

CHAPTER II

RELATED STUDIES

I. INTRODUCTION

When evaluation and analysis of large scale testing is being undertaken, many questions present themselves. Have studies of a similar nature been carried out? In what areas have they been undertaken? What methods have been used in analysing the tests? Within the limits of available information, how does the population sample and subject area compare with the present study? How do the results relate to the findings in the present study?

Evaluations of grade IX mathematics on a province-wide basis in Alberta are limited in number. Two of the studies, similar to the present one in procedure, are based on a different course in mathematics which was in effect until 1952. The only recent Alberta study is limited to a single subject area, algebra, and to a single geographic location, Edmonton.

American investigations are based on courses in mathematics different from that in Alberta, so that no valid comparisons of evaluations can be made. However, the conclusions drawn with regard to fundamental weaknesses in the students' work are closely related to the conclusions in the Alberta studies.

II. ALBERTA STUDIES

In 1941, Cooper (2) made a study of a sample numbering four hundred fifty grade IX Departmental examination papers in algebra and geometry, the combined course as it was taught at that time. One-third of the sample was taken from each of city, town and rural areas in order that the study should not be biased by the environment of the student.

A separate analysis was made of each question or part question on the examination paper. The major types of thinking which went into the solution of the question, from reading to setting down the answer, were listed. Answers were classified

separately for city, town, and rural papers as correct, incorrect or not attempted. The predominant types of errors, together with the frequency with which they occurred were noted. Suggestions for remedial teaching relative to the common errors found in the particular question were offered.

Cooper found that the mean of the algebra scores of city students was 35.00, of town students was 36.30, and of rural students was 35.45. The mean of the geometry scores of city students was 29.20, of town students was 31.05 and of rural students was 29.30. He concluded that the teaching and learning in the three areas were about equal.

Suggestions for remedial teaching were offered. Definitions must be made more meaningful by application to concrete situations. Pupils should be taught the value of diagrams in interpreting problems. They should be taught to verify answers by employing alternate methods of solution and to use critical judgment to determine whether or not an answer is reasonable. There is need for remedial work in computational skills. Also more attention should be given to reading in mathematics.

Cooper observed that errors were made in the marking of the examination papers. The procedure was that each examiner marked an entire paper. He suggested an alternative method whereby each examiner would be responsible for marking a single question. Thus the examiner would be required to remember only a limited number of alternative answers and a limited distribution of partial values.

In 1948, Paulson (7) analysed the lowest B group examination papers to determine the standards of mathematical achievement as found in the grade IX examination papers written that year. Of the three hundred papers examined, one hundred fifty-seven had a raw score of 40, which was equated to 45 per cent, while one hundred forty-three had a raw score of 41, or 46 per cent.

Paulson was concerned with finding answers for the following questions:

"a) What do students at this level know?
b) What do students at this level not know?
c) Are definitions meaningful to the student?

d) Do students know proofs and constructions?

e) Does the students' work show any evidence of logical thought, or does their work reflect only memorization?

f) Does the examination paper test the students' power to specialize and apply abstract theory to particular problems and situations?

g) Does the examination paper test the students' power to generalize and theorize?

h) Was the examination fair?" (7: 1)

Paulson summarized his answer to the question, "What do students at this level know?" with statements from which the following examples were taken:

55 per cent can find the product of two decimal fractions;

81 per cent can find the sum of six signed numbers;

75 per cent can divide a common fraction by a common fraction. (7: 160)

Similar statements were made in answer to the question, "What do students at this level not know?" The following are examples:

81 per cent cannot find the area of a circle, given the diameter;

59 per cent cannot find the value of an unknown quantity which will satisfy an equation of the first degree;

76 per cent cannot select the "necessarily true" converse from a group of five propositions. (7: 161)

A knowledge of definitions indicates an exact understanding of concepts, and Paulson found that only slightly over one-third of the marks allotted for concepts were earned by the students in the lower B group. He concluded that definitions were not meaningful to most of these students.

Paulson found that the question involving a geometric proof was the most poorly answered of all the questions on the examination paper. Not one student earned full marks for that question. He found that their written work indicated a complete lack of insight and understanding of the procedure in setting down a proof.

There was little evidence of logical or critical thinking as indicated by the number of completely absurd answers. Proofs were offered for diagrams that were different from those on the examination paper, indicating that students had relied on memorization rather than reasoning for geometric solutions.

Paulson found that the examination did not test the pupils' ability to apply abstract theory. Sixty-three per cent of the paper tested theory, while thirty-one per cent tested relationships and six per cent tested concepts. However, he also found that the great majority of the lower B students did not have the ability to apply abstract theory to concrete situations.

Although the examination paper did provide many chances for the students to generalize, the results showed that their ability to do so was very limited.

Paulson found that the examination paper covered the course very well, and that the allocation of marks corresponded favorably with the distribution of the content of the course. However, he did feel that there could have been more problems applicable to the mathematics of everyday life. There were no constructions. On the whole the test items were fair and the values were proportional to the difficulty. The paper was not too long for the time allowed. The format of the paper was criticized because there was insufficient space provided for rough work, resulting in students having to transfer answers from the backs of the sheets to the appropriate space.

Paulson summarized his findings by stating that the pupils in the lower B group in 1948 had a weak grounding in mathematics. They did not have the ability to analyse problems, nor to use critical judgment in evaluating their solutions.

Muir (6) compared the proficiency in algebra of grade IX students in the Edmonton Public Schools in 1938 and in 1959. In 1959 a representative sample of four hundred eighty-one grade IX students from the Edmonton Junior High Schools wrote the 1938 grade IX Departmental examination in algebra and also the general ability test of the same year.

The raw scores on both tests were compared with those of a random sample of two hundred three Edmonton students who wrote

the same tests in 1938. Muir found that the mean raw scores for the 1938 and 1959 samples were 31.36 and 26.66 respectively on the algebra test, and 56.49 and 60.78 respectively on the general test. Although the students in 1959 were brighter according to the scores they made on the general ability test of 1938, they failed to do as well in algebra as those in 1938. The differences in mean scores were tested statistically and found to be highly significant. Muir concluded that there has been a decline in proficiency in algebra at the grade IX level in the Edmonton Public Schools since 1938.

Muir considered factors which might be expected to influence the test scores of the two samples. He found that in 1959 the mean I.Q. of the students was seven points higher, the mean age was three months younger, the mean attendance was fifteen days higher, and the mean class enrolment was twelve less than the corresponding figures for the class of 1938. Teachers' qualifications were equally as good in 1959 as in 1938. The effect of a "last minute" review and the motivation of a final examination (the 1959 test was written on June 12 and was not a final examination) was offset by the shorter school year in 1938. Considering all factors, the 1959 group should have performed as well as, if not better than, the 1938 group.

Muir considered possible causes for the decline in competence in algebra. Socio-economic conditions and changes in pupils' attitudes toward education had an effect. But Muir felt that a more important cause was the change in emphasis in the teaching of mathematics whereby the development of habits of logical thinking and the ability to analyse problems was given precedence over mechanical proficiency in computation. He advocated a reversal of this emphasis on the grounds that computational skills are of immediate and lasting benefit. He felt that the maturity and ability of high school students is limited to the extent that they are unable to benefit extensively from a course which gives precedence to the study of relationships and generalizations.

III. AMERICAN STUDIES

In 1955 Peak (8: 1574) conducted a survey to evaluate the efficiency of the teaching of first year algebra. His purpose was two-fold. First, he sought to determine whether the teaching of algebra had enabled students to analyse and solve problems, to apply their knowledge of arithmetic to algebra, to apply mathematics to real life situations, to understand the language of mathematics and to make reliable estimates of answers. Second, he undertook to evaluate the achievement of the pupils in relation to the training of their teachers.

The Efficiency Test in First Year Algebra was given to 3327 pupils in 119 schools in Illinois, Indiana, Kentucky, Michigan, Ohio and Wisconsin. The results were analysed by separate items. If seventy-five per cent or more of a class obtained the correct answer to a question, the class was considered successful.

Peak found that the teaching had not been efficient in many areas. Pupils did not apply their knowledge of arithmetic to algebra. They did not have clear concepts of terms and symbols. They could not analyse problems, recognize unnecessary steps in the solutions of problems, nor organize solutions in the most efficient manner. They could not properly translate an equation into a verbal statement nor estimate answers. However, he found that they had been taught to find mistakes in their solutions and to apply problem solving to real life situations.

Peak found that the best results on questions testing fundamental operations and location of errors were obtained from classes whose teachers had had more than eight years of experience in teaching. Classes whose teachers had four or more years of college training did better on fundamentals, but did not do better in other areas, than classes taught by undergraduates. Classes whose teachers had over five years of college training did better on questions involving exponents and the use of symbols. Peak concluded that strengthening of the preparation of mathematics teachers was necessary in order to improve the students' achievement.

In 1960 Pruett (9: 505) analysed the grade equivalents in mathematics and science for grade IX pupils in six hundred eighteen Indiana schools, both public and private. In mathematics the test used was the California Mathematics Test (Advanced). A frequency distribution was made of the grade equivalent tested, also an item analysis of a sample of 468 answer sheets from thirteen selected schools. Comparisons of grade placement achievement were made both in relation to distribution of scores and to the item analysis.

Pruett found that, in general, girls achieved higher scores in mathematics than boys. Schools in session for longer terms and schools with high enrolments produced better mathematics students than those with shorter terms and fewer pupils per class. Pupils with high scores in the reasoning section of the test did not necessarily obtain high scores in the total test. Nor did schools which ranked high in reasoning sections of the test necessarily rank high in the fundamentals section. This disparity of achievement did not seem to be related to the length of the school term, nor to the sizes or types of schools.

The item analysis indicated that no particular questions contributed to the poor scores. Pupils who received low scores answered some of the items correctly in all parts of the test, but did not answer as many items correctly as the pupils who ranked in the upper and middle groups. The percentages of correct answers indicated that items relating to decimals and fractions were the easiest, while those relating to roots and exponents were the most difficult.

There was no marked difference in the achievement of the schools. When they were ranked in order of scores attained from first to thirteenth, the difference between the highest and lowest represented only four per cent of the total possible score. This was an average of 5.8 more correct items per students for the school ranking first than for the school ranking thirteenth.

IV. CONCLUSION

The current study attempts an analysis and comparison of the factual knowledge of mathematics possessed by the five categories of grade IX students as identified by the Department of Education. In this respect it differs from other studies. Cooper (2), as did the writer, based his survey on a sample taken from the entire province, but analysed his results according to the type of school rather than the category of the student. Paulson (7) concentrated on one particular category, the lowest of the B group. The complete course in mathematics constituted the scope of these investigations. Muir (6) confined his study both to a single area of the course, algebra, and to a limited group of students, those in the Edmonton Public Schools.

The procedure common to all the investigations was the item analysis used by the writer. It is impractical to compare statistical results since there is no common basis on which evaluations were made.

One fact, however, was brought out forcibly by all the investigators. They felt that the standard of work in grade IX could be improved. Criticisms of student achievement which were common to all the surveys including the present one are lack of mechanical proficiency, lack of ability in analysing problems and failure to apply critical judgment in evaluation of answers. Paulson (7) felt that students should be able to generalize and apply abstract thinking to a greater degree, while Muir (6) felt that the present course places too much emphasis on these aspects at the expense of mechanical aptitude.

American studies went beyond those in Alberta in relating students' achievements to such factors as enrolments, length of school term, and qualifications and experience of the teachers. It is a field that would bear further investigation in Alberta.

CHAPTER III

RESEARCH PLAN AND DESIGN

I. SOURCE OF THE DATA

The data for this study came from a proportional systematic sample selected from the total of all grade IX mathematics papers written in the Province of Alberta in June, 1960. It was decided that the sample should contain the same proportion of papers in each of the H, A, B, C and D categories as were issued in the province.

The Examinations Branch of the Department of Education had previously conducted a survey based on one-fifteenth of all the grade IX mathematics papers written that year. The papers were selected in the following manner. The papers coming in from points throughout the province for marking had been numbered consecutively in the order in which they had been received. Out of the first ten numbers, number three was chosen by random selection. Papers numbered 3, 18, 33, and every fifteenth paper thereafter, were drawn from the total population. These papers made up the sample used by the Examinations Branch.

At the suggestion of the Examinations Branch, every third paper from their sample was drawn to complete the smaller sample analysed in this report. The papers used by the Examinations Branch for their survey were made available in rank order of raw scores. Three hundred eighty-nine papers were selected, ranging from a low raw score of 6 to a high of 141.

II. CLASSIFICATION OF THE DATA

The raw scores used by the Examinations Branch to establish letter gradings for the grade IX mathematics papers in 1960 are shown in Table II, page 16.

According to this classification, the distribution of the sample papers is indicated in Table III, page 16.

TABLE II

RAW SCORES USED TO ESTABLISH LETTER GRADINGS FOR GRADE IX MATHEMATICS PUPILS IN ALBERTA, 1960

Raw Score	Letter Grading
111 - 162 inclusive	H
75 - 110 inclusive	A
42 - 74 inclusive	B
22 - 41 inclusive	C
0 - 21 inclusive	D

TABLE III

DISTRIBUTION OF LETTER GRADINGS ON SAMPLE PAPERS

Letter Grading	Number of Papers
H	39
A	100
B	135
C	78
D	37
Total	389 papers

The percentage of sample papers in each category compared with the distribution for the province as a whole is shown in Table IV, below.

TABLE IV

COMPARISON OF LETTER GRADINGS OF SAMPLE PAPERS WITH PROVINCIAL EXAMINATION PAPERS FOR GRADE IX MATHEMATICS, 1960

	Sample Per Cent	Provincial Per Cent
H	10.03	10.07
A	25.71	25.20
B	34.70	34.43
C	20.05	20.34
D	9.51	9.96
	100.00	100.00

III. DERIVATION OF STATISTICAL MEANS AND STANDARD DEVIATIONS

The mean of the raw scores of all the papers used in this study was computed, as well as the standard deviation. The mean was found by using the formula

$$M = \frac{\Sigma x}{N}$$

where "x" is the raw score of each paper and "N" the number of papers. The sum of the raw scores was found to be 24,794. Thus the mean of the raw scores,

$$M = \frac{24,794}{389} \qquad \text{was } 63.74.$$

The standard deviation was found by using the formula

$$S = \sqrt{\frac{\Sigma X^2}{N} - \overline{X}^2},$$

where "X" is the raw score of each paper, $\overline{X}$ the mean of the raw

scores and "N" the number of papers. The sum of the squares of the raw scores was found to be 2,012,409. Thus,

$$S = \sqrt{\frac{2,012,409}{389} - (63.74)^2} = 33.32.$$

According to information supplied by the office of the Co-ordinator of Tests and Measurements, of the Department of Education, the mean for the province was 63.01 and the standard deviation 33.1. The sample mean differs from the population mean by 0.73. Referring to Garrett's (5: 446) table of areas under the normal curve, the chances are 66 out of 100 that means from samples of 389 will depart ±0.73 or more from the population mean. Therefore there is not a significant difference between the sample and population means.

IV. PROCEDURE

The first step in the investigation of the sample papers was the preparation of an item analysis. The principles tested in each question were listed. (See Appendix B) A separate frequency distribution was made for each category H, A, B, C and D. Each item was checked according to whether the principle was correct, incorrect, or not attempted. In solutions involving more than one principle, each principle was examined independently of those that preceded or followed it, and credit was given for knowledge of that principle without regard to the values assigned by the markers. The rough work was considered as well as the formal statements.

The totals in the frequency distribution were converted into percentages. Where the same principle occurred more than once on the examination paper, the totals were combined.

A special problem arose in connection with the optional questions, 36 and 37, and 38 and 39. The figures listed under NOT ATTEMPTED apply to those cases in which the pupil attempted a solution but did not carry out all the steps. In addition, there were cases where the pupil did not attempt either question of the optional pairs.

Tables IX to CII on pages 31 to 77 show for each item in the analysis, the numbers and percentages of pupils in each category who obtained a correct answer, an incorrect answer, or who did not attempt the item.

The relative competence of the H, A, B, C, and D categories of students was computed for each of the subject areas of arithmetic, algebra, geometry and graphic study. For each category the total number of correct items was expressed as a percentage of the total number of items tested in that area. The results, expressed graphically, are shown in Figures 1 to 4 on pages 78 to 81.

The relative competence of each category of students in the four areas of arithmetic, algebra, geometry and graphic study is shown in Figures 5 to 9 on pages 83 to 87.

A summary of the percentages of students who had each principle correct is shown in Tables CIII to CVI, pages 88 to 94. This summary emphasizes the areas of strength and weakness of all categories of pupils.

CHAPTER IV

THE EXAMINATION PAPER

If the examination is to be used as a criterion for testing the knowledge of the pupils with respect to the course as taught in grade IX, then the paper must be representative of the course. An investigation was made to find out how well the examination paper did test the material covered in the text book, which constitutes the mathematics course in grade IX. This was done in two ways. First, the percentage of the marks allotted on the examination paper to each of the four areas of arithmetic, algebra, geometry and graphic study, was compared with the percentage of pages in the text book devoted to the same four areas. Second, the number of principles tested in each of the four areas expressed as a percentage of the total number of principles tested on the examination paper, was compared with the part of the text book devoted to each of the four areas, expressed as a percentage of the whole book.

The curriculum guide (4) indicated the chapters of the text dealing with arithmetic, algebra, geometry and graphic representation. For purposes of this study, pages 266 to 275 in Chapter VIII (Signed Numbers) were classified as algebra rather than as arithmetic. The 403 pages in the text book contain 145 pages of arithmetic, 111 pages of algebra, 115 pages of geometry and 25 pages of graphic study. The percentage distribution is 36.0, 29.3, 28.5 and 6.2 respectively.

An analysis of the examination paper was made. For each question or part question, a similar exercise was located in the text book. In this way it was possible to classify each question under arithmetic, algebra, geometry or graphic representation according to the chapters listed for each of these areas in the curriculum guide.

Table V, page 21, shows each question or part question, the chapter in the text from which it was taken, and the value assigned to it.

TABLE V

TABLE OF VALUES GIVEN TO SUBJECT AREAS ON GRADE IX MATHEMATICS EXAMINATION, 1960

Arithmetic Chapters I, II, VI, VII, VIII, IX, XI			Algebra Chapters I, II, XII			Geometry Chapters III, IV, V, X			Graph Chapter IX		
Question	Chapter	Value	Question	Chapter	Value	Question	Chapter	Value	Question	Chapter	Value
1	XI	-*									
			2	III	2						
			3	III	2						
4	VI	2									
5	VII	2									
6	XI	2									
						7	XII	2			
8	II	2									
						9	I	2			
10	II	2									
11	II	2									
						12	XII	2			
						13	I	2			
			14	X	2						
						15	XII	2			
			16	V	2						
17	II	2									
			18	III	2						
19a	VII	1									
19b	II	1									

*Question 1 was deleted because, of the five answers given from which the pupil was required to select the correct answer, none was correct.

Question	Chapter	Value	Question	Chapter	Value	Question	Chapter	Value	Question	Chapter	Value
19c	XI	1									
19d	XI	1									
			19e	X	1						
			19f	V	1						
			19g	III	1						
20a	VIII	2									
			20b	V	2						
			20c	X	2						
20d	II	2									
			20e	VIII	2						
						20f	XII	2			
20g	II	2									
			21a	V	1						
			21b	V	1						
									21c1	IX	1
									21c2	IX	1
									21c3	IX	1
			22a	IV	1						
			22b	IV	1						
			22c	IV	1						
			22d	IV	1						
23	VII	3									
24	VI	2									
25	VII	2									
						26	XII	5			
			27a	III	3						
			27b	III	2						
			27c	III	3						
			27d	III	3						
			27e	III	3						
			28	X	6						

Question	Chapter	Value	Question	Chapter	Value	Question	Chapter	Value	Question	Chapter	Value
29	XI	4									
			30a	V	3						
			30b	X	5						
			30c	X	6						
						31a	I	I			
						31b	I	1			
						31c	I	1			
						31d	I	1			
						32a	XII	4			
						32b	XII	1			
						32c	XII	2			
						33a	I	3			
						33b	I	3			
						33c	I	4			
			34a	V	3						
			34b	V	3						
34c	II	3									
									35a	IX	2
									35b	IX	4
									35c	IX	2
36a	XI	3)									
36b	XI	3)	Optional questions								
37	XI	6)									
			38	V	6)						
			39	V	6)	Optional questions					
Total		44	Total		71	Total		38	Total		11

The total mark on the paper was 164, not including question number 1. The two-mark value assigned to question 1 was not included in the raw score used for determining provincial gradings because, of the five answers given from which the pupil was required to select the correct answer, none was correct.

A comparison of the examination paper with the text book with respect to the percentage that covers each subject is shown in Table VI, page 25.

A comparison of the emphasis on the principles between the examination paper and the content by pages in the text book is given in Table VII, page 25. A list of the principles required in the solution of all the questions on the examination paper was made. Altogether ninety-four principles were tested. The thirty-six principles in arithmetic constitute thirty-eight per cent of all the principles tested, or 2.3 per cent more than the content of the text book devoted to arithmetic. Similarly, the twenty-seven principles in algebra make up 28.7 per cent of the principles tested, or 0.6 per cent less than the corresponding content of the textbook; the twenty-five principles in geometry, or 26.6 per cent of the principles tested, give a comparison of 1.9 per cent less emphasis in the examination than is devoted to geometry in the text book; and the six principles in graphic study, or 6.4 per cent, indicates the examination devoted 0.2 per cent more of its total to graphic study than did the text book.

The ninety-four principles, together with the questions on the examination paper from which they were taken, are itemized in Table VIII, page 26.

TABLE VI

COMPARISON OF CONTENT OF EXAMINATION PAPER IN TERMS OF VALUES ASSIGNED TO QUESTIONS, WITH CONTENT IN TEXT BOOK, GRADE IX MATHEMATICS, 1960

	Examination Paper Per Cent	Text Book Per Cent	± Difference
Arithmetic	26.7	36.0	- 9.3
Algebra	43.3	29.3	+14.0
Geometry	23.3	28.5	- 5.2
Graph	6.7	6.2	+ 0.5
	100.0	100.0	

TABLE VII

COMPARISON OF CONTENT OF EXAMINATION PAPER IN TERMS OF PRINCIPLES TESTED, WITH CONTENT IN TEXT BOOK, GRADE IX MATHEMATICS, 1960

	Examination Paper		Text Book	±Difference
	Number of Principles	Per Cent	Per Cent	
Arithmetic	36	38.3	36.0	+ 2.3
Algebra	27	28.7	29.3	- 0.6
Geometry	25	26.6	28.5	- 1.9
Graph	6	6.4	6.2	+ 0.2
	94	100.0	100.0	

TABLE VIII

PRINCIPLES

Question	Principles
	ARITHMETIC
20g	1. Division by a decimal;
20g, 34c	2. Rounding off numbers;
8, 19b	3. Relation of units in another system of measure;
10	4. Comparison of area measure;
11	5. Finding surface area of rectangular solid;
11	6. Conversion of units;
17	7. Application of Pythagorean theorem;
17	8. Finding perimeter of a parallelogram;
20d	9. Knowledge of formula for area of a triangle;
20d, 34c, 36a, 36b	10. Solving a formula;
24	11. Knowledge of highest common factor;
24	12. Knowledge of lowest common multiple;
4	13. Knowledge of composite numbers;
4	14. Knowledge of prime factors;
23, 5	15. Adding fractions;
23, 5	16. Subtracting fractions;
5	17. Multiplying fractions;
30a	18. Converting mixed number to improper fraction;
23	19. Simplifying complex fraction;
25.	20. Changing a fraction to a recurring decimal;
19a	21. Understanding of exponents;
27a, 30b, 30c, 35a	22. Adding signed numbers;
20a, 30c	23. Multiplying signed numbers;
20a, 30c	24. Dividing signed numbers;
6	25. Finding interest;

TABLE VIII (continued)

Question	Principle
21c3	26. Finding a percentage of a number;
21c2	27. Finding what percentage one number is of another;
19c	28. Finding a number when percentage is given;
19d	29. Changing mills to per cent;
29	30. Finding first discount;
29	31. Finding second discount;
29, 29	32. Finding reduced price;
37	33. Finding cost given per cent gain;
37	34. Finding cost given per cent loss;
37	35. Determining gain or loss;
37	36. Determining amount of gain or loss.
	ALGEBRA
2, 14, 27a, 30b, 30c, 34c, 36a, 36b	1. Substitution;
27a	2. Understanding of exponents;
19e, 20e, 3, 30b, 27b, 27e, 28, 38	3. Adding algebraic terms;
27d, 27d, 27d	4. Subtracting algebraic terms;
27e, 27e	5. Multiplying algebraic terms;
3, 19e, 27c, 27c, 27c	6. Dividing algebraic terms;
18	7. Knowledge of reciprocal of fraction;
18	8. Knowledge of coefficient of x;
18	9. Multiplying algebraic fractions;
19g	10. Finding square root of a trinomial;
20b, 36a, 36b	11. Changing the subject of a formula;
21a	12. Application of a formula;
21b	13. Definition - meaning of a "variable";
34a	14. Knowledge of formula for area of a parallelogram;

TABLE VIII (continued)

Question	Principle
34a	15. Knowledge of formula for area of a semi-circle;
34b	16. Knowledge of formula for circumference of a semi-circle;
19f	17. Finding relationship of area to radius of a circle;
16	18. Knowledge of inverse variation;
20e, 28, 39	19. Removing parentheses;
20c	20. Inserting parentheses;
28, 28, 28	21. Writing an algebraic expression;
22a, 22b, 22c, 22d, 28, 30a, 38, 39	22. Writing an algebraic equation;
26, 30a, 30c, 38	23. Multiplying each side of equation by L.C.D.;
30a, 30b, 39	24. Adding term to each side of equation;
28, 30b, 30c, 30c, 38, 39	25. Subtracting term from each side of equation;
20f, 28, 26, 30a, 30b, 30c, 38, 39	26. Dividing each side of equation by same factor;
28	27. Interpreting solution of a problem.
	GEOMETRY
13	1. Recognition of geometric figures;
31a, 31b, 31c, 31d	2. Characteristics of geometric figures;
13	3. Knowledge of correct spelling;
33a, 33b	4. Naming angles;
33b	5. Bisecting a given angle;
33b	6. Constructing an angle equal to another angle;
33c, 33c	7. Bisecting a chord;
33c	8. Finding a center of a circle;

TABLE VIII (continued)

Question	Principle
33c	9. Drawing a circle;
33a	10. Constructing an angle of 90°;
33a	11. Constructing an angle of 45°;
9	12. Reading bearings;
12	13. Knowledge of number of degrees in a triangle;
12	14. Knowledge of isosceles triangles;
12	15. Knowledge of equality of base angles of isosceles triangles;
12, 15, 20f	16. Knowledge of supplement of an angle;
15	17. Knowledge of complement of an angle;
20f, 32a	18. Knowledge of vertically opposite angles;
32a	19. Knowledge of alternate angles;
32a	20. Knowledge of corresponding angles;
32a	21. Knowledge of adjacent angles;
32b	22. Knowledge of transversals;
32c, 32c	23. Relation of pairs of angles;
26	24. Knowledge of relationship of sides of similar triangles;
7	25. Knowledge of mode.
	GRAPHS
21c	1. Knowledge of type of graph;
35c	2. Knowledge of character of graph;
35b, 35b	3. Drawing a graph;
35b	4. Naming graphs;
35c	5. Reading co-ordinates of point of intersection;
21c2, 21c3	6. Knowledge of number of degrees in central angle of a circle.

CHAPTER V

THE DATA

For each of the principles tested on the examination paper, a frequency table was made, indicating the number of students who had the principle correct, the number incorrect, and the number who did not attempt the principle. Where a certain principle appeared more than once on the examination paper, the totals were combined. The totals were then converted to percentages, with the percentages rounded off to the nearest one-hundredth.

Tables IX to XLIV inclusive, pages 31 to 48, summarize the findings for the section of the examination paper dealing with arithmetic.

Tables XLV to LXXI inclusive, pages 49 to 62, summarize the findings for the section of the examination paper dealing with algebra.

Tables LXXII to XCVI inclusive, pages 62 to 74, summarize the findings for the section of the examination paper dealing with geometry.

Tables XCVII to CII inclusive, pages 75 to 77, summarize the findings for the section of the examination paper dealing with graphic study.

As one would expect, in almost every case the findings for the percentages of students obtaining a correct answer to a principle decrease from the H category down through the D category. It is interesting to note, however, that this decrease is by no means uniform from one principle to the next.

Figures 1, 2, 3 and 4, pages 78, 79, 80 and 81, indicate graphically the relative competence of students of the five categories in the four fields of arithmetic, algebra, geometry, and graphic study. To obtain the data for these figures, the total number of principles in each area was found and this was expressed as a percentage of the total number of principles tested.

I. ARITHMETIC

Principle 1. Division by a decimal.

Number of times this principle appeared on the examination paper - 1.

TABLE IX
PRINCIPLE 1

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	22	56.41	46	46.00	34	25.18	15	19.23	1	2.70
Incorrect	16	41.03	45	45.00	85	62.96	55	70.51	27	72.97
Not Attempted	1	2.56	9	9.00	16	11.86	8	10.26	9	24.32
Totals	39	100.00	100	100.00	135	100.00	78	99.99	37	99.99

Principle 2. Rounding off numbers.

Number of times this principle appeared on the examination paper - 2.

TABLE X
PRINCIPLE 2

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	44	56.41	57	78.50	34	12.59	19	12.18	8	10.81
Incorrect	20	25.64	74	37.00	116	42.96	67	42.95	25	33.78
Not Attempted	14	17.95	69	34.50	120	44.45	70	44.87	41	55.40
Totals	78	100.00	200	100.00	270	100.00	156	100.00	74	99.99

Principle 3. Relation of units in another system of measure. Number of times this principle appeared on the examination paper - 2.

TABLE XI

PRINCIPLE 3

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	34	43.59	66	33.00	86	31.85	46	29.49	16	21.62
Incorrect	36	46.16	105	52.50	134	49.63	86	55.13	46	62.16
Not Attempted	8	10.26	29	14.50	50	18.52	24	15.38	12	16.22
Totals	78	100.01	200	100.00	270	100.00	156	100.00	74	100.00

Principle 4. Comparison of area measure. Number of times this principle appeared on the examination paper - 1.

TABLE XII

PRINCIPLE 4

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	5	12.82	10	10.00	19	14.08	12	15.29	6	16.22
Incorrect	31	79.49	86	86.00	109	80.74	64	82.05	28	75.67
Not Attempted	3	7.69	4	4.00	7	5.18	2	2.56	3	8.11
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 5. Finding surface area of rectangular solid.
Number of times this principle appeared on the examination paper - 1.

TABLE XIII
PRINCIPLE 5

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	27	69.23	48	48.00	48	35.56	9	11.54	4	10.81
Incorrect	11	28.21	51	51.00	85	62.96	68	87.18	31	83.78
Not Attempted	1	2.56	1	1.00	2	1.48	1	1.28	2	5.41
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 6. Conversion of units.
Number of times this principle appeared on the examination paper - 1.

TABLE XIV
PRINCIPLE 6

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	15	38.46	11	16.00	11	8.15	3	3.85	1	2.70
Incorrect	23	58.98	88	88.00	122	90.37	74	94.87	34	91.89
Not Attempted	1	2.56	1	1.00	2	1.48	1	1.28	2	5.41
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 7. Application of Pythagorean Theorem.
Number of times this principle appeared on the examination paper - 1.

TABLE XV

PRINCIPLE 7

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	37	94.87	70	70.00	67	49.63	33	42.31	14	37.84
Incorrect	2	5.13	27	27.00	65	48.15	43	55.13	21	56.76
Not Attempted	0	0.00	3	3.00	3	2.22	2	2.56	2	5.41
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.01

Principle 8. Finding perimeter of a parallelogram.
Number of times this principle appeared on the examination paper - 1.

TABLE XVI

PRINCIPLE 8

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	37	94.87	60	60.00	72	53.33	18	23.08	8	21.62
Incorrect	2	5.13	37	37.00	60	44.45	58	74.36	27	72.97
Not Attempted	0	0.00	3	3.00	3	2.22	2	2.56	2.	5.41
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 9. Knowledge of formula for area of a triangle. Number of times this principle appeared on the examination paper - 1.

TABLE XVII
PRINCIPLE 9

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	38	97.44	85	85.00	82	60.74	32	41.03	5	13.51
Incorrect	1	2.56	12	12.00	34	25.18	27	34.61	17	45.95
Not Attempted	0	0.00	3	3.00	19	14.08	19	24.36	15	40.54
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 10. Solving a formula.
Number of times this principle appeared on the examination paper - 4.

TABLE XVIII
PRINCIPLE 10

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	130	82.00	177	50.57	129	32.57	39	17.57	11	11.46
Incorrect	17	16.00	115	32.86	141	35.61	100	45.04	39	40.62
Not Attempted	3	2.00	58	16.57	126	31.82	83	37.29	46	47.92
Totals	150	100.00	350	100.00	396	100.00	222	100.00	96	100.00

Principle 11. Knowledge of highest common factor.

Number of times this principle appeared on the examination paper - 1.

TABLE XIX

PRINCIPLE 11

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	32	82.05	63	63.00	59	43.70	10	12.82	2	5.41
Incorrect	7	17.95	36	36.00	61	45.18	53	67.95	24	64.86
Not Attempted	0	0.00	1	1.00	15	11.11	15	19.23	11	29.73
Totals	39	100.00	100	100.00	135	99.99	78	100.00	37	100.00

Principle 12. Knowledge of lowest common multiple.

Number of times this principle appeared on the examination paper - 1.

TABLE XX

PRINCIPLE 12

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	22	56.41	50	50.00	32	23.70	6	7.69	1	2.70
Incorrect	16	41.03	48	48.00	84	62.22	58	74.36	25	67.57
Not Attempted	1	2.56	2	2.00	19	14.08	14	17.95	11	29.73
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 13. Knowledge of composite numbers.

Number of times this principle appeared on the examination paper - 1.

TABLE XXI

PRINCIPLE 13

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	30	76.92	57	57.00	44	32.59	14	17.95	7	18.92
Incorrect	9	23.08	42	42.00	89	65.93	63	80.79	29	78.38
Not Attempted	0	0.00	1	1.00	2	1.48	1	1.28	1	2.70
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 14. Knowledge of prime factors.

Number of times this principle appeared on the examination paper - 1.

TABLE XXII

PRINCIPLE 14

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	36	92.31	96	96.00	113	83.70	60	76.92	30	81.08
Incorrect	3	7.69	3	3.00	20	14.82	17	21.79	6	16.22
Not Attempted	0	0.00	1	1.00	2	1.48	1	1.28	1	2.70
Totals	39	100.00	100	100.00	135	100.00	78	99.99	37	100.00

Principle 15. Adding fractions.
Number of times this principle appeared on the examination paper - 2.

TABLE XXIII
PRINCIPLE 15

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	74	94.87	152	76.00	189	69.99	59	37.82	21	28.38
Incorrect	3	3.85	34	17.00	67	24.82	76	48.72	40	54.06
Not Attempted	1	1.28	14	7.00	14	5.19	21	13.46	13	17.57
Totals	78	100.00	200	100.00	270	100.00	156	100.00	74	100.01

Principle 16. Subtracting fractions.
Number of times this principle appeared on the examination paper - 2.

TABLE XXIV
PRINCIPLE 16

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	75	96.15	155	77.50	186	68.88	63	40.38	24	32.43
Incorrect	2	2.56	32	16.00	70	25.93	73	46.79	37	50.00
Not Attempted	1	1.28	13	6.50	14	5.19	20	12.82	13	17.57
Totals	78	99.99	200	100.00	270	100.00	156	99.99	74	100.00

Principle 17. Multiplying fractions.

Number of times this principle appeared on the examination paper - 1.

TABLE XXV

PRINCIPLE 17

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	36	92.31	55	55.00	64	47.41	16	20.51	2	5.41
Incorrect	3	7.69	39	39.00	63	46.67	57	73.08	31	83.78
Not Attempted	0	0.00	6	6.00	8	5.93	5	6.41	4	10.81
Totals	39	100.00	100	100.00	135	100.01	78	100.00	37	100.00

Principle 18. Converting mixed number to improper fraction.

Number of times this principle appeared on the examination paper - 1.

TABLE XXVI

PRINCIPLE 18

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	32	82.05	80	80.00	80	59.26	27	34.61	9	24.32
Incorrect	1	2.56	4	4.00	3	2.22	4	5.13	3	8.11
Not Attempted	6	15.39	16	16.00	52	38.52	47	60.26	25	67.57
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

<u>Principle 19</u>. Simplifying complex fraction.
Number of times this principle appeared on the examination paper - 1.

TABLE XXVII
PRINCIPLE 19

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	35	89.74	77	77.00	76	56.30	13	16.67	2	5.41
Incorrect	2	5.13	12	12.00	34	25.18	21	26.92	16	43.24
Not Attempted	2	5.13	11	11.00	25	18.52	44	56.41	19	51.35
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

<u>Principle 20</u>. Changing a fraction to a recurring decimal.
Number of times this principle appeared on the examination paper - 1.

TABLE XXVIII
PRINCIPLE 20

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	25	64.10	60	60.00	55	40.74	19	24.36	4	10.81
Incorrect	14	35.90	36	36.00	64	47.41	47	60.26	20	54.06
Not Attempted	0	0.00	4	4.00	16	11.86	12	15.39	13	35.14
Totals	39	100.00	100	100.00	135	100.01	78	100.01	37	100.01

Principle 21. Understanding of exponents.

Number of times this principle appeared on the examination paper - 1.

TABLE XXIX

PRINCIPLE 21

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	36	92.31	76	76.00	62	45.93	23	29.49	2	5.41
Incorrect	3	7.69	24	24.00	73	54.07	53	67.95	32	86.49
Not Attempted	0	0.00	0	00.00	0	0.00	2	2.56	3	8.11
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.01

Principle 22. Adding signed numbers.

Number of times this principle appeared on the examination paper - 4.

TABLE XXX

PRINCIPLE 22

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	128	82.05	269	67.25	257	47.59	62	19.87	16	10.81
Incorrect	19	12.18	70	17.50	102	18.88	85	27.24	34	22.97
Not Attempted	9	5.77	61	15.25	181	33.52	165	52.89	98	66.22
Totals	156	100.00	400	100.00	540	99.99	312	100.00	148	100.00

Principle 23. Multiplying signed numbers.
Number of times this principle appeared on the examination paper - 1.

TABLE XXXI
PRINCIPLE 23

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	36	92.31	85	85.00	99	73.33	39	50.00	10	27.03
Incorrect	3	7.69	15	15.00	35	25.92	31	39.74	17	45.95
Not Attempted	0	0.00	0	0.00	1	0.74	8	10.26	10	27.03
Totals	39	100.00	100	100.00	135	99.99	78	100.00	37	100.01

Principle 24. Dividing signed numbers.
Number of times this principle appeared on the examination paper - 2.

TABLE XXXII
PRINCIPLE 24

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	65	83.33	119	59.50	118	48.70	26	16.67	9	12.16
Incorrect	3	3.85	22	11.00	35	12.97	49	31.41	18	24.33
Not Attempted	10	12.82	59	29.50	117	43.33	81	51.92	47	63.52
Totals	78	100.00	200	100.00	270	100.00	156	100.00	74	100.01

Principle 25. Finding interest.

Number of times this principle appeared on the examination paper - 1.

TABLE XXXIII

PRINCIPLE 25

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	27	69.23	47	47.00	38	28.15	21	26.92	3	8.11
Incorrect	12	30.77	53	53.00	97	71.85	57	73.08	32	86.49
Not Attempted	0	0.00	0	0.00	0	0.00	0	0.00	2	5.41
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.01

Principle 26. Finding a per cent of a number.

Number of times this principle appeared on the examination paper - 1.

TABLE XXXIV

PRINCIPLE 26

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	32	82.05	78	78.00	67	49.63	19	24.36	6	16.22
Incorrect	7	17.95	13	13.00	51	37.78	39	50.00	22	59.46
Not Attempted	0	0.00	9	9.00	17	12.59	20	25.64	9	24.32
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 27. Finding what per cent one number is of another. Number of times this principle appeared on the examination paper - 1.

TABLE XXXV
PRINCIPLE 27

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	34	87.18	89	89.00	86	63.70	27	34.61	8	21.62
Incorrect	5	12.82	10	10.00	38	28.15	41	52.56	23	62.16
Not Attempted	0	0.00	1	1.00	11	8.15	10	12.82	6	16.22
Totals	39	100.00	100	100.00	135	100.00	78	99.99	37	100.00

Principle 28. Finding a number when per cent is given. Number of times this principle appeared on the examination paper - 1.

TABLE XXXVI
PRINCIPLE 28

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	38	97.44	78	78.00	51	37.78	15	19.23	4	10.81
Incorrect	0	0.00	16	16.00	64	47.41	52	66.67	22	59.46
Not Attempted	1	2.56	6	6.00	20	14.82	11	14.10	11	29.73
Totals	39	100.00	100	100.00	135	100.01	78	100.00	37	100.00

Principle 29. Changing mills to per cent.

Number of times this principle appeared on the examination paper - 1.

TABLE XXXVII

PRINCIPLE 29

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	28	71.79	50	50.00	43	31.85	20	25.64	2	5.41
Incorrect	11	28.21	40	40.00	71	52.59	43	55.13	22	59.46
Not Attempted	0	0.00	10	10.00	21	15.56	15	19.23	13	35.14
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.01

Principle 30. Finding first discount.

Number of times this principle appeared on the examination paper - 1.

TABLE XXXVIII

PRINCIPLE 30

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	34	87.18	76	76.00	80	59.26	31	39.74	6	16.22
Incorrect	4	10.26	11	11.00	8	5.93	15	19.23	10	27.03
Not Attempted	1	2.56	13	13.00	47	34.82	32	41.03	21	56.76
Totals	39	100.00	100	100.00	135	100.01	78	100.00	37	100.01

Principle 31. Finding second discount.
Number of times this principle appeared on the examination paper - 1.

TABLE XXXIX
PRINCIPLE 31

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	33	84.61	71	71.00	62	45.93	18	23.08	2	5.41
Incorrect	3	7.69	16	16.00	26	19.26	27	34.61	13	35.14
Not Attempted	3	7.69	13	13.00	47	34.82	33	42.31	22	59.46
Totals	39	99.99	100	100.00	135	100.01	78	100.00	37	100.01

Principle 32. Finding reduced price.
Number of times this principle appeared on the examination paper - 2.

TABLE XL
PRINCIPLE 32

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	69	88.46	143	71.50	128	47.41	38	24.36	4	5.41
Incorrect	5	6.41	23	11.50	29	10.74	37	23.72	3	4.05
Not Attempted	4	5.13	34	17.00	113	41.85	81	51.92	67	90.54
Totals	78	100.00	200	100.00	270	100.00	156	100.00	74	100.00

Principle 33. Finding cost given per cent gain.
Number of times this principle appeared on the examination paper - 1.

TABLE XLI*

PRINCIPLE 33

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	1	33.33	2	9.52	1	1.92	1	4.55	0	0.00
Incorrect	2	66.67	15	71.43	34	65.38	13	59.09	8	40.00
Not Attempted	0	0.00	4	19.05	17	32.69	8	36.36	12	60.00
Totals	3	100.00	21	100.00	52	99.99	22	100.00	20	100.00

*From an optional question. Because of the small number who attempted this question, the percentages are not considered highly significant.

Principle 34. Finding cost given per cent loss.
Number of times this principle appeared on the examination paper - 1.

TABLE XLII*

PRINCIPLE 34

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	2	66.67	2	9.52	0	0.00	0	0.00	0	0.00
Incorrect	1	33.33	14	66.67	32	61.54	14	63.64	7	35.00
Not Attempted	0	0.00	5	23.81	20	38.46	8	36.36	13	65.00
Totals	3	100.00	21	100.00	52	100.00	22	100.00	20	100.00

*From an optional question. Because of the small number who attempted this question, the percentages are not considered highly significant.

Principle 35. Determining gain or loss.

Number of times this principle appeared on the examination paper - 1.

TABLE XLIII*

PRINCIPLE 35

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	1	33.33	6	28.57	14	26.92	4	18.18	1	5.00
Incorrect	2	66.67	13	61.91	32	61.54	16	72.72	17	85.00
Not Attempted	0	0.00	2	9.52	6	11.54	2	9.09	2	10.00
Totals	3	100.00	21	100.00	52	100.00	22	99.99	20	100.00

*From an optional question. Because of the small number who attempted this question, the percentages are not considered highly significant.

Principle 36. Determining amount of gain or loss.

Number of times this principle appeared on the examination paper - 1.

TABLE XLIV*

PRINCIPLE 36

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	2	66.67	3	14.28	1	1.92	0	0.00	0	0.00
Incorrect	1	33.33	14	66.67	34	65.38	20	90.90	12	60.00
Not Attempted	0	0.00	4	19.05	17	32.69	2	9.09	8	40.00
Totals	3	100.00	21	100.00	42	99.99	22	99.99	20	100.00

*From an optional question. Because of the small number who attempted this question, the percentages are not considered highly significant.

II. ALGEBRA

Principle 37. Substitution.

Number of times this principle appeared on the examination paper - 7.

TABLE XLV
PRINCIPLE 37

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	260	84.97	463	61.73	338	36.11	83	15.34	19	7.79
Incorrect	36	11.77	200	26.67	389	41.56	271	50.75	115	47.12
Not Attempted	10	3.27	87	11.60	209	22.33	180	33.71	110	45.08
Totals	306	100.01	750	100.00	936	100.00	534	100.00	244	99.99

Principle 38. Understanding of exponents.

Number of times this principle appeared on the examination paper - 1.

TABLE XLVI
PRINCIPLE 38

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	39	100.00	95	95.00	119	88.14	58	74.36	13	35.14
Incorrect	0	0.00	5	5.00	14	10.37	18	23.08	18	48.65
Not Attempted	0	0.00	0	0.00	2	1.48	2	2.56	6	16.22
Totals	39	100.00	100	100.00	135	99.99	78	100.00	37	100.01

Principle 39. Adding algebraic terms.

Number of times this principle appeared on the examination paper - 8.

TABLE XLVII
PRINCIPLE 39

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	276	90.49	622	81.59	625	64.13	170	29.82	24	8.85
Incorrect	20	6.56	104	12.48	223	21.80	252	44.21	144	53.14
Not Attempted	9	2.95	51	5.92	175	14.07	148	25.96	103	38.01
Totals	303	100.00	777	99.99	1023	100.00	570	99.99	271	100.00

Principle 40. Subtracting algebraic terms.

Number of times this principle appeared on the examination paper - 3.

TABLE XLVIII
PRINCIPLE 40

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	113	96.38	250	83.33	286	70.62	97	41.45	24	21.62
Incorrect	4	3.42	50	16.67	110	27.16	125	53.42	70	63.06
Not Attempted	0	0.00	0	0.00	9	2.22	12	5.13	17	15.32
Totals	117	100.00	300	100.00	405	100.00	234	100.00	111	100.00

Principle 41. Multiplying algebraic terms.

Number of times this principle appeared on the examination paper - 2.

TABLE XLIX

PRINCIPLE 41

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	72	92.31	167	83.50	180	66.67	48	30.77	8	10.81
Incorrect	6	7.69	32	16.00	85	31.48	93	59.62	58	78.38
Not Attempted	0	0.00	1	0.50	5	1.85	15	9.61	8	10.81
Totals	78	100.00	200	100.00	270	100.00	156	100.00	74	100.00

Principle 42. Dividing algebraic terms.

Number of times this principle appeared on the examination paper - 5.

TABLE L

PRINCIPLE 42

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	175	89.74	404	81.60	417	61.78	110	28.21	22	11.89
Incorrect	19	9.74	84	16.60	225	33.33	250	64.10	114	61.62
Not Attempted	1	0.52	12	1.80	33	4.89	30	7.69	49	26.49
Totals	195	100.00	500	100.00	675	100.00	390	100.00	185	100.00

Principle 43. Knowledge of reciprocal of a fraction.
Number of times this principle appeared on the examination paper - 1.

TABLE LI
PRINCIPLE 43

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	37	94.87	52	52.00	47	34.82	16	20.51	3	8.11
Incorrect	2	5.13	46	46.00	85	62.96	62	79.49	31	83.78
Not Attempted	0	0.00	2	2.00	3	2.22	0	0.00	3	8.11
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 44. Knowledge of arithmetic coefficient of x.
Number of times this principle appeared on the examination paper - 1.

TABLE LII
PRINCIPLE 44

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	39	100.00	77	77.00	78	57.79	39	50.00	17	45.95
Incorrect	0	0.00	21	21.00	54	40.00	39	50.00	17	45.95
Not Attempted	0	0.00	2	2.00	3	2.22	0	0.00	3	8.11
Totals	39	100.00	100	100.00	135	100.01	78	100.00	37	100.01

Principle 45. Multiplying algebraic fractions.

Number of times this principle appeared on the examination paper - 1.

TABLE LIII

PRINCIPLE 45

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	39	100.00	74	74.00	75	55.56	46	59.97	20	54.06
Incorrect	0	0.00	24	24.00	57	42.22	32	41.03	14	37.84
Not Attempted	0	0.00	2	2.00	3	2.22	0	0.00	3	8.11
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.01

Principle 46. Finding square root of a trinomial.

Number of times this principle appeared on the examination paper - 1.

TABLE LIV

PRINCIPLE 46

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	21	53.84	20	20.00	10	7.41	5	6.41	1	2.70
Incorrect	16	41.03	68	68.00	101	74.81	44	56.41	18	48.65
Not Attempted	2	5.13	12	12.00	24	17.78	28	37.18	18	48.65
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 47. Changing the subject of a formula.
Number of times this principle appeared on the examination paper - 3.

TABLE LV
PRINCIPLE 47

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	79	71.17	120	48.00	48.	18.39	10	6.94	0	0.00
Incorrect	11	9.91	73	29.20	109	41.76	66	45.83	30	50.85
Not Attempted	21	18.92	57	22.80	104	39.85	68	47.22	29	49.15
Totals	111	100.00	250	100.00	261	100.00	144	99.99	59	100.00

Principle 48. Application of a formula.
Number of times this principle appeared on the examination paper - 1.

TABLE LVI
PRINCIPLE 48

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	36	92.31	62	62.00	95	70.37	49	62.82	18	48.65
Incorrect	3	7.69	37	37.00	39	28.89	29	37.18	16	43.24
Not Attempted	0	0.00	1	1.00	1	0.74	0	0.00	3	8.11
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 49. Definition - Meaning of a "variable". Number of times this principle appeared on the examination paper - 1.

TABLE LVII

PRINCIPLE 49

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	35	89.74	78	78.00	81	60.00	25	32.05	9	24.32
Incorrect	4	10.26	21	21.00	52	38.52	50	64.10	20	54.06
Not Attempted	0	0.00	1	1.00	2	1.48	3	3.85	8	21.62
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 50. Knowledge of formula for area of a parallelogram. Number of times this principle appeared on the examination paper - 1.

TABLE LVIII

PRINCIPLE 50

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	31	79.49	52	52.00	31	22.96	8	10.26	4	10.81
Incorrect	8	20.51	47	47.00	84	62.22	50	64.10	20	54.06
Not Attempted	0	0.00	1	1.00	20	14.82	20	25.64	13	35.14
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.01

Principle 51. Knowledge of formula for area of a semicircle.

Number of times this principle appeared on the examination paper - 1.

TABLE LIX

PRINCIPLE 51

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	33	84.61	74	74.00	67	49.63	20	25.64	1	2.70
Incorrect	6	15.39	25	25.00	44	32.59	34	43.59	21	56.76
Not Attempted	0	0.00	1	1.00	24	17.78	24	30.77	15	40.54
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 52. Knowledge of formula for circumference of a semicircle.

Number of times this principle appeared on the examination paper - 1

TABLE LX

PRINCIPLE 52

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	12	30.77	6	6.00	2	1.48	0	0.00	0	0.00
Incorrect	26	66.67	88	88.00	93	68.89	49	62.82	18	48.65
Not Attempted	1	2.56	6	6.00	40	29.63	29	37.18	19	51.35
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 53. Finding relationship of area to radius of circle. Number of times this principle appeared on the examination paper - 1.

TABLE LXI

PRINCIPLE 53

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	33	84.61	52	52.00	47	34.82	13	16.67	1	2.70
Incorrect	6	15.39	47	47.00	85	62.96	64	82.05	34	91.89
Not Attempted	0	0.00	1	1.00	3	2.22	1	1.28	2	5.41
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 54. Knowledge of inverse variation. Number of times this principle appeared on the examination paper - 1

TABLE LXII

PRINCIPLE 54

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	34	87.18	81	81.00	84	62.22	36	46.16	8	21.62
Incorrect	5	12.82	19	19.00	49	36.30	42	53.84	29	78.38
Not Attempted	0	0.00	0	0.00	2	1.48	0	0.00	0	0.00
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 55. Removing parentheses.
Number of times this principle appeared on the examination paper - 3.

TABLE LXIII
PRINCIPLE 55

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	70	82.35	128	58.98	122	40.80	22	11.89	0	0.00
Incorrect	4	4.71	29	13.36	52	17.39	51	27.57	28	32.94
Not Attempted	11	12.94	60	27.65	125	41.81	112	60.54	57	67.06
Totals	85	100.00	217	99.99	299	100.00	185	100.00	85	100.00

Principle 56. Inserting parentheses.
Number of times this principle appeared on the examination paper - 1.

TABLE LXIV
PRINCIPLE 56

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	38	97.44	73	73.00	59	43.70	6	7.69	1	2.70
Incorrect	1	2.56	24	24.00	66	48.89	66	84.61	32	86.49
Not Attempted	0	0.00	3	3.00	10	7.41	6	7.69	4	10.81
Totals	39	100.00	100	100.00	135	100.00	78	99.99	37	100.00

Principle 57. Writing an algebraic expression.

Number of times this principle appeared on the examination paper - 3.

TABLE LXV

PRINCIPLE 57

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	90	76.92	135	45.00	76	18.76	9	3.84	1	0.90
Incorrect	23	19.66	115	38.33	176	43.46	100	42.74	35	31.53
Not Attempted	4	3.42	50	16.67	153	37.78	125	53.42	75	67.57
Totals	117	100.00	300	100.00	405	100.00	234	100.00	111	100.00

Principle 58. Writing an algebraic equation.

Number of times this principle appeared on the examination paper - 9.

TABLE LXVI

PRINCIPLE 58

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	247	90.48	530	76.37	498	54.31	157	30.13	39	15.92
Incorrect	22	8.06	140	20.17	317	34.57	271	52.02	118	48.16
Not Attempted	4	1.46	24	3.46	102	11.12	93	17.85	88	35.92
Totals	273	100.00	694	100.00	917	100.00	521	100.00	245	100.00

Principle 59. Multiplying each side of equation by L.C.D. Number of times this principle appeared on the examination paper - 4.

TABLE LXVII
PRINCIPLE 59

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	129	82.55	196	51.99	105	21.74	14	5.43	0	0.00
Incorrect	13	10.07	73	19.36	122	25.26	38	14.73	7	5.69
Not Attempted	7	7.38	108	28.65	256	53.00	206	79.84	116	94.31
Totals	149	100.00	377	100.00	483	100.00	258	100.00	123	100.00

Principle 60. Adding term to each side of equation. Number of times this principle appeared on the examination paper - 3.

TABLE LXVIII
PRINCIPLE 60

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	80	94.12	185	85.25	205	68.56	74	40.00	12	14.12
Incorrect	4	4.71	17	7.83	36	12.04	38	20.54	11	12.94
Not Attempted	1	1.17	15	6.91	58	19.40	73	39.46	62	72.94
Totals	85	100.00	217	99.99	299	100.00	185	100.00	85	100.00

<u>Principle</u> <u>61</u>. Subtracting term from each side of equation. Number of times this principle appeared on the examination paper - 6.

TABLE LXIX
PRINCIPLE 61

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	174	89.23	348	70.44	279	43.12	69	19.18	13	7.60
Incorrect	7	3.59	58	11.74	110	17.00	70	18.90	18	10.54
Not Attempted	14	7.18	88	17.82	258	39.88	226	61.92	140	81.86
Totals	195	100.00	494	100.00	647	100.00	365	100.00	171	100.00

<u>Principle</u> <u>62</u>. Dividing each side of equation by same factor. Number of times this principle appeared on the examination paper - 9.

TABLE LXX
PRINCIPLE 62

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	245	89.74	485	69.88	380	41.44	97	18.62	8	3.27
Incorrect	8	2.93	61	8.79	138	15.05	106	20.34	41	16.73
Not Attempted	20	7.33	148	21.32	399	43.51	318	61.04	196	80.00
Totals	273	100.00	694	99.99	917	100.00	521	100.00	245	100.00

Principle 63. Interpreting solution of a problem.
Number of times this principle appeared on the examination paper - 1.

TABLE LXXI
PRINCIPLE 63

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	22	56.41	29	29.00	14	10.37	0	0.00	0	0.00
Incorrect	7	17.95	26	26.00	26	19.26	21	26.92	9	24.32
Not Attempted	10	25.64	45	45.00	95	70.37	57	73.08	28	75.67
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	99.99

III. GEOMETRY

Principle 64. Recognition of geometric figures.
Number of times this principle appeared on the examination paper - 1.

TABLE LXXII
PRINCIPLE 64

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	38	97.44	81	81.00	92	68.15	41	52.56	10	27.03
Incorrect	1	2.56	18	18.00	43	31.85	37	47.44	26	70.27
Not Attempted	0	0.00	1	1.00	0	0.00	0	0.00	1	2.70
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 65. Characteristics of geometric figures.
Number of times this principle appeared on the examination paper - 4.

TABLE LXXIII
PRINCIPLE 65

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	69	44.23	93	23.25	66	12.41	32	10.26	8	5.41
Incorrect	82	52.56	280	70.00	372	68.89	214	68.59	97	65.54
Not Attempted	5	3.21	27	6.75	102	18.70	66	21.15	43	29.05
Totals	156	100.00	400	100.00	540	100.00	312	100.00	148	100.00

Principle 66. Knowledge of correct spelling.
Number of times this principle appeared on the examination paper - 1.

TABLE LXXIV
PRINCIPLE 66

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	39	100.00	88	88.00	103	76.30	41	52.56	21	56.76
Incorrect	0	0.00	11	11.00	32	23.70	37	47.44	15	40.54
Not Attempted	0	0.00	1	1.00	0	0.00	0	0.00	1	2.70
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 67. Naming angles.
Number of times this principle appeared on the examination paper - 2.

TABLE LXXV
PRINCIPLE 67

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	65	83.33	122	61.00	88	32.59	44	28.20	13	17.57
Incorrect	0	0.00	33	16.50	69	25.56	34	21.80	23	31.08
Not Attempted	13	16.67	45	22.50	113	41.85	78	50.00	38	51.35
Totals	78	100.00	200	100.00	270	100.00	156	100.00	74	100.00

Principle 68. Bisecting a given angle.
Number of times this principle appeared on the examination paper - 1.

TABLE LXXVI
PRINCIPLE 68

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	35	89.74	66	66.00	82	60.74	31	39.74	9	24.32
Incorrect	0	0.00	0	0.00	9	6.67	3	3.85	2	5.41
Not Attempted	4	10.26	34	34.00	44	32.59	44	56.41	26	70.27
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 69. Constructing an angle equal to another angle. Number of times this principle appeared on the examination paper - 1.

TABLE LXXVII

PRINCIPLE 69

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	27	69.23	43	43.00	42	31.11	13	16.67	0	0.00
Incorrect	10	25.64	47	47.00	79	58.52	50	64.10	31	83.78
Not Attempted	2	5.13	10	10.00	14	10.37	15	19.23	6	16.22
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 70. Bisecting a chord. Number of times this principle appeared on the examination paper - 2.

TABLE LXXVIII

PRINCIPLE 70

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	73	93.59	129	64.50	109	40.37	45	28.85	9	12.16
Incorrect	0	0.00	5	2.50	10	3.70	11	7.05	2	2.70
Not Attempted	5	6.41	66	33.00	151	55.93	100	64.10	63	85.13
Totals	78	100.00	200	100.00	270	100.00	156	100.00	74	99.99

Principle 71. Finding the center of a circle.

Number of times this principle appeared on the examination paper - 1.

TABLE LXXIX
PRINCIPLE 71

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	36	92.31	61	61.00	50	37.04	19	24.36	4	10.81
Incorrect	1	2.56	26	26.00	46	34.07	39	50.00	23	62.16
Not Attempted	2	5.13	13	13.00	39	28.89	20	25.64	10	27.03
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 72. Drawing a circle.

Number of times this principle appeared on the examination paper - 1.

TABLE LXXX
PRINCIPLE 72

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	39	100.00	78	78.00	75	55.56	40	51.28	20	54.06
Incorrect	0	0.00	3	3.00	13	9.63	14	17.95	5	13.51
Not Attempted	0	0.00	19	19.00	47	34.82	24	30.77	12	32.43
Totals	39	100.00	100	100.00	135	100.01	78	99.99	37	100.00

Principle 73. Constructing an angle of 90°.
Number of times this principle appeared on the examination paper - 1.

TABLE LXXXI
PRINCIPLE 73

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	36	92.31	74	74.00	55	40.74	24	30.77	6	16.22
Incorrect	2	5.13	13	13.00	42	31.11	27	34.61	13	35.14
Not Attempted	1	2.56	13	13.00	38	28.15	27	34.61	18	48.65
Totals	39	100.00	100	100.00	135	100.00	78	99.99	37	100.01

Principle 74. Constructing an angle of 45°.
Number of times this principle appeared on the examination paper - 1.

TABLE LXXXII
PRINCIPLE 74

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	35	89.74	84	84.00	83	61.48	38	48.72	14	37.84
Incorrect	3	7.69	6	6.00	25	18.52	25	32.05	16	43.24
Not Attempted	1	2.56	10	10.00	27	20.00	15	19.23	7	18.92
Totals	39	99.99	100	100.00	135	100.00	78	100.00	37	100.00

Principle 75. Reading bearings.

Number of times this principle appeared on the examination paper - 1.

TABLE LXXXIII

PRINCIPLE 75

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	17	43.59	22	22.00	21	15.56	7	8.97	2	5.41
Incorrect	22	56.41	77	77.00	113	83.70	71	91.03	35	94.59
Not Attempted	0	0.00	1	1.00	1	0.74	0	0.00	0	0.00
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 76. Knowledge of number of degrees in a triangle.

Number of times this principle appeared on the examination paper - 1.

TABLE LXXXIV

PRINCIPLE 76

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	34	87.18	85	85.00	87	64.44	42	53.85	14	37.84
Incorrect	5	12.82	15	15.00	48	35.56	35	44.87	23	62.16
Not Attempted	0	0.00	0	0.00	0	0.00	1	1.28	0	0.00
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 77. Knowledge of isosceles triangle.

Number of times this principle appeared on the examination paper - 1.

TABLE LXXXV

PRINCIPLE 77

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	34	87.18	85	85.00	83	61.48	42	53.85	14	37.84
Incorrect	5	12.82	15	15.00	52	38.52	35	44.87	23	62.16
Not Attempted	0	0.00	0	0.00	0	0.00	1	1.28	0	0.00
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 78. Knowledge of equality of base angles of isosceles triangle.

Number of times this principle appeared on the examination paper - 1.

TABLE LXXXVI

PRINCIPLE 78

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	34	87.18	83	83.00	83	61.48	42	53.85	14	37.84
Incorrect	5	12.82	17	17.00	52	38.52	35	44.87	23	62.16
Not Attempted	0	0.00	0	0.00	0	0.00	1	1.28	0	0.00
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 79. Knowledge of supplement of an angle.
Number of times this principle appeared on the examination paper - 3.

TABLE LXXXVII
PRINCIPLE 79

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	107	91.45	252	84.00	235	58.02	86	36.76	17	15.32
Incorrect	10	8 .55	34	11.33	141	34.82	121	51.71	79	71.17
Not Attempted	0	0.00	14	4.67	29	7.16	27	11.53	15	13.51
Totals	117	100.00	300	100.00	405	100.00	234	100.00	111	100.00

Principle 80. Knowledge of complement of an angle.
Number of times this principle appeared on the examination paper - 1.

TABLE LXXXVIII
PRINCIPLE 80

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	38	97.44	88	88.00	83	61.48	25	32.05	3	8.11
Incorrect	1	2.56	12	12.00	50	37.04	52	66.67	33	89.19
Not Attempted	0	0.00	0	0.00	2	1.48	1	1.28	1	2.70
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 81. Knowledge of vertically opposite angles. Number of times this principle appeared on the examination paper - 2.

TABLE LXXIX
PRINCIPLE 81

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	74	94.87	162	81.00	156	57.78	49	31.41	13	17.57
Incorrect	4	5.13	32	16.00	103	38.15	86	55.13	50	67.57
Not Attempted	0	0.00	6	3.00	11	4.07	21	13.46	11	14.86
Totals	78	100.00	200	100.00	270	100.00	156	100.00	74	100.00

Principle 82. Knowledge of alternate angles. Number of times this principle appeared on the examination paper - 1.

TABLE XC
PRINCIPLE 82

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	29	74.36	54	54.00	51	37.78	16	20.51	5	13.51
Incorrect	10	25.64	45	45.00	83	61.48	59	75.64	29	78.38
Not Attempted	0	0.00	1	1.00	1	0.74	3	3.85	3	8.11
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 83. Knowledge of corresponding angles.

Number of times this principle appeared on the examination paper - 1.

TABLE XCI

PRINCIPLE 83

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	35	89.74	73	73.00	71	52.59	33	42.31	10	27.03
Incorrect	4	10.26	26	26.00	63	46.67	42	53.84	24	64.86
Not Attempted	0	0.00	1	1.00	1	0.74	3	3.85	3	8.11
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 84. Knowledge of adjacent angles.

Number of times this principle appeared on the examination paper - 1.

TABLE XCII

PRINCIPLE 84

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	39	100.00	82	82.00	88	65.19	40	51.28	13	35.14
Incorrect	0	0.00	16	16.00	44	32.59	35	44.87	20	54.06
Not Attempted	0	0.00	2	2.00	3	2.22	3	3.75	4	10.81
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.01

Principle 85. Knowledge of transversals.
Number of times this principle appeared on the examination paper - 1.

TABLE XCIII
PRINCIPLE 85

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	38	97.44	76	76.00	75	53.56	29	37.18	3	8.11
Incorrect	1	2.56	14	14.00	34	25.18	32	41.03	25	67.57
Not Attempted	0	0.00	10	10.00	26	19.26	17	21.79	9	24.32
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 86. Relation of pairs of angles.
Number of times this principle appeared on the examination paper - 2.

TABLE XCIV
PRINCIPLE 86

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	47	60.25	69	34.50	63	23.33	18	11.54	1	1.35
Incorrect	26	33.33	91	45.50	125	46.30	71	45.51	33	44.59
Not Attempted	5	6.41	40	20.00	82	30.37	67	42.95	40	54.06
Totals	78	99.99	200	100.00	270	100.00	156	100.00	74	100.00

Principle 87. Knowledge of proportion of sides of similar triangles.

Number of times this principle appeared on the examination paper - 1.

TABLE XCV
PRINCIPLE 87

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	36	92.31	56	56.00	31	22.96	2	2.56	1	2.70
Incorrect	2	5 .13	24	24.00	52	38.52	35	44.87	23	62.16
Not Attempted	1	2.56	20	20.00	52	38.52	41	52.56	13	35.14
Totals	39	100.00	100	100.00	135	100.00	78	99.99	37	100.00

Principle 88. Knowledge of mode.

Number of times this principle appeared on the examination paper - 1.

TABLE XCVI
PRINCIPLE 88

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	25	64.10	44	44.00	58	42.96	21	26.92	2	5.41
Incorrect	13	33.33	54	54.00	74	54.12	57	73.08	31	83.78
Not Attempted	1	2.56	2	2.00	3	2.22	0	0.00	4	10.81
Totals	39	99.99	100	100.00	135	100.00	78	100.00	37	100.00

IV. GRAPHIC STUDY

Principle 89. Knowledge of type of graph.

Number of times this principle appeared on the examination paper - 1.

TABLE XCVII

PRINCIPLE 89

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	39	100.00	99	99.00	132	97.78	74	94.87	32	86.49
Incorrect	0	0.00	1	1.00	1	0.74	2	2.56	2	5.41
Not Attempted	0	0.00	0	0.00	2	1.48	2	2.56	3	8.11
Totals	39	100.00	100	100.00	135	100.00	78	99.99	37	100.00

Principle 90. Knowledge of character of graph.

Number of times this principle appeared on the examination paper - 1.

TABLE XCVIII

PRINCIPLE 90

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	20	51.28	48	48.00	30	22.22	13	16.67	0	0.00
Incorrect	15	38.46	29	29.00	43	31.85	21	26.92	14	37.84
Not Attempted	4	10.26	23	23.00	62	45.93	44	56.41	23	62.16
Totals	39	100.00	100	100.00	135	100.00	78	100.00	37	100.00

Principle 91. Drawing line graph.

Number of times this principle appeared on the examination paper - 2.

TABLE XCIX

PRINCIPLE 91

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	67	86.00	161	80.50	160	59.26	52	33.33	6	8.11
Incorrect	4	5.13	15	7.50	34	12.59	28	17.95	24	32.43
Not Attempted	7	8.97	24	12.00	76	28.15	76	48.72	44	59.46
Totals	78	100.00	200	100.00	270	100.00	156	100.00	74	100.00

Principle 92. Naming graphs.

Number of times this principle appeared on the examination paper - 1.

TABLE C

PRINCIPLE 92

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	28	71.79	62	62.00	54	40.00	14	17.95	6	16.22
Incorrect	2	5.13	0	0.00	0	0.00	1	1.28	3	8.11
Not Attempted	9	23.08	38	38.00	81	60.00	63	80.77	28	75.67
Totals	39	100.00	100	100.00	135	100.00	78	99.99	37	100.00

Principle 93. Reading co-ordinates of point of intersection. Number of times this principle appeared on the examination paper - 1.

TABLE CI

PRINCIPLE 93

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	31	79.49	60	60.00	54	40.00	11	14.10	1	2.70
Incorrect	4	10.26	26	26.00	41	30.37	24	30.77	13	35.14
Not Attempted	4	10.26	14	14.00	40	29.63	43	55.13	23	62.16
Totals	39	100.01	100	100.00	135	100.00	78	100.00	37	100.00

Principle 94. Knowledge of number of degrees in central angle of a circle.

Number of times this principle appeared on the examination paper - 2.

TABLE CII

PRINCIPLE 94

	H		A		B		C		D	
	No.	%	No.	%	No.	%	No.	%	No.	%
Correct	77	98.72	187	93.50	227	84.07	104	66.67	43	37.84
Incorrect	1	1.28	2	1.00	16	5.93	23	14.74	16	41.89
Not Attempted	0	0.00	11	5.50	27	10.00	29	18.59	15	20.27
Totals	78	100.00	200	100.00	270	100.00	156	100.00	74	100.00

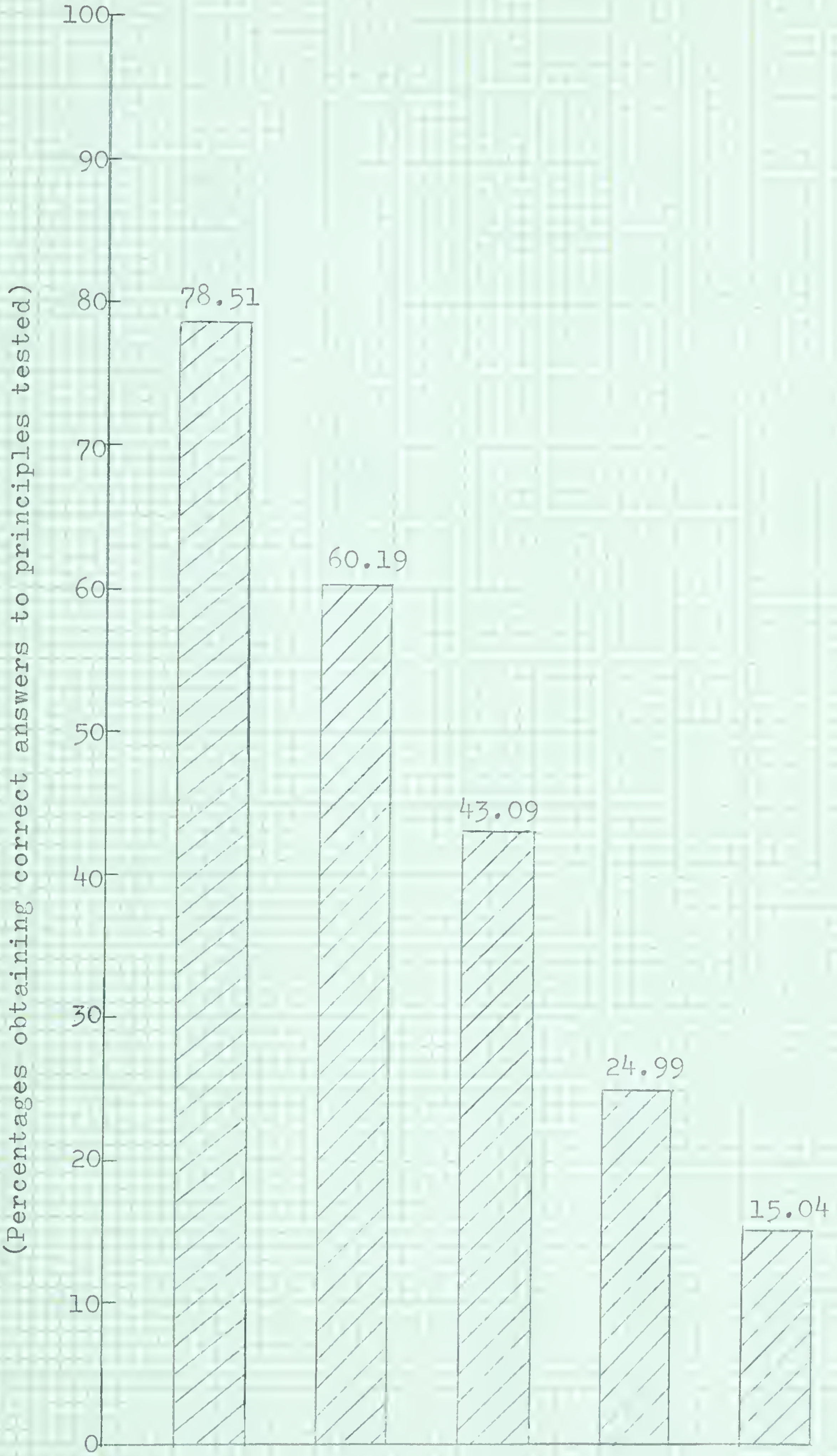

Figure 1. Relative Competence of the Five Categories of Students in Arithmetic

[illegible]

Figure 2. Relative Competence of the Five Categories of Students in Algebra

[illegible]

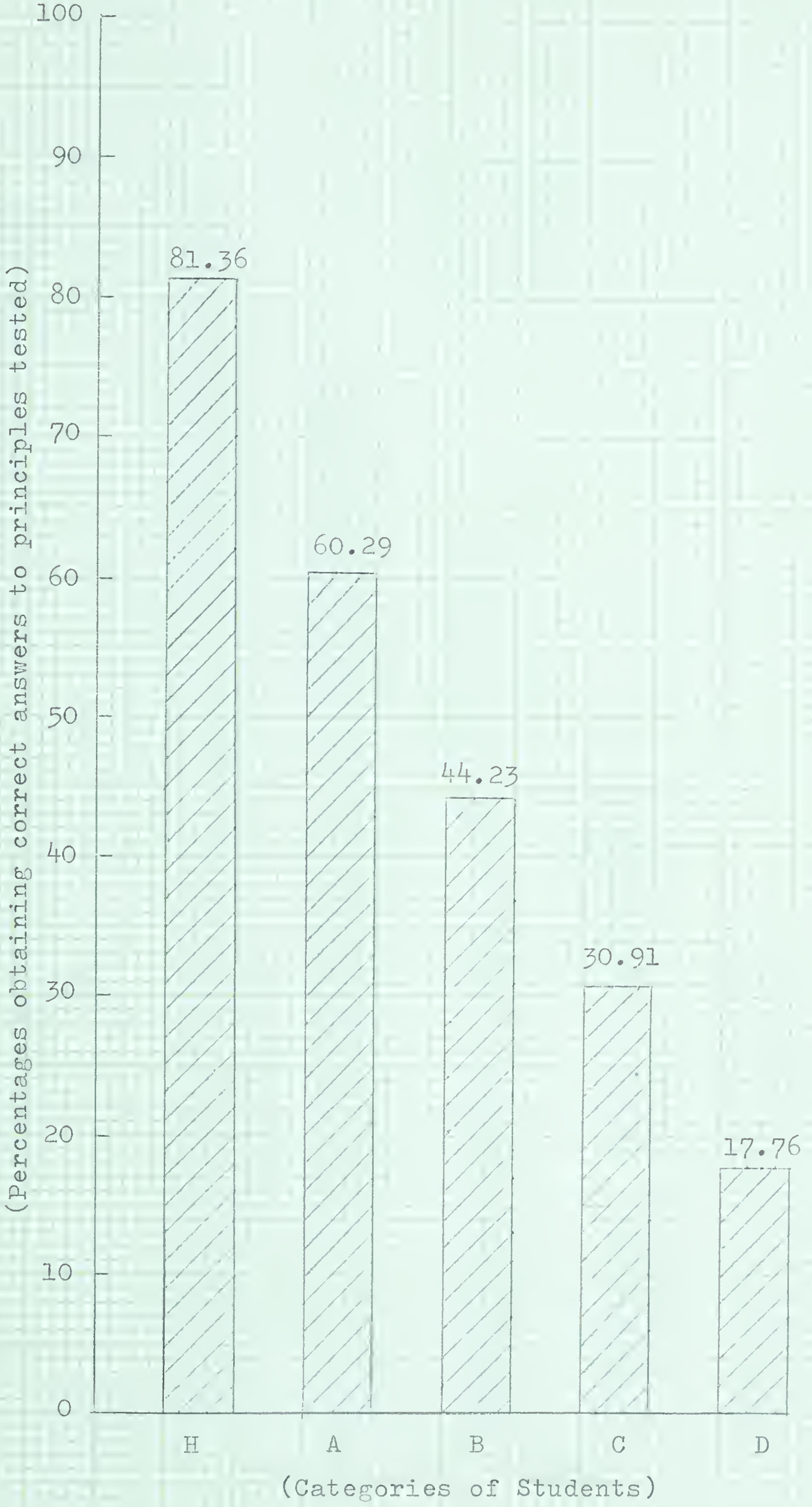

Figure 3. Relative Competence of the Five Categories of Students in Geometry

[illegible]

[illegible]

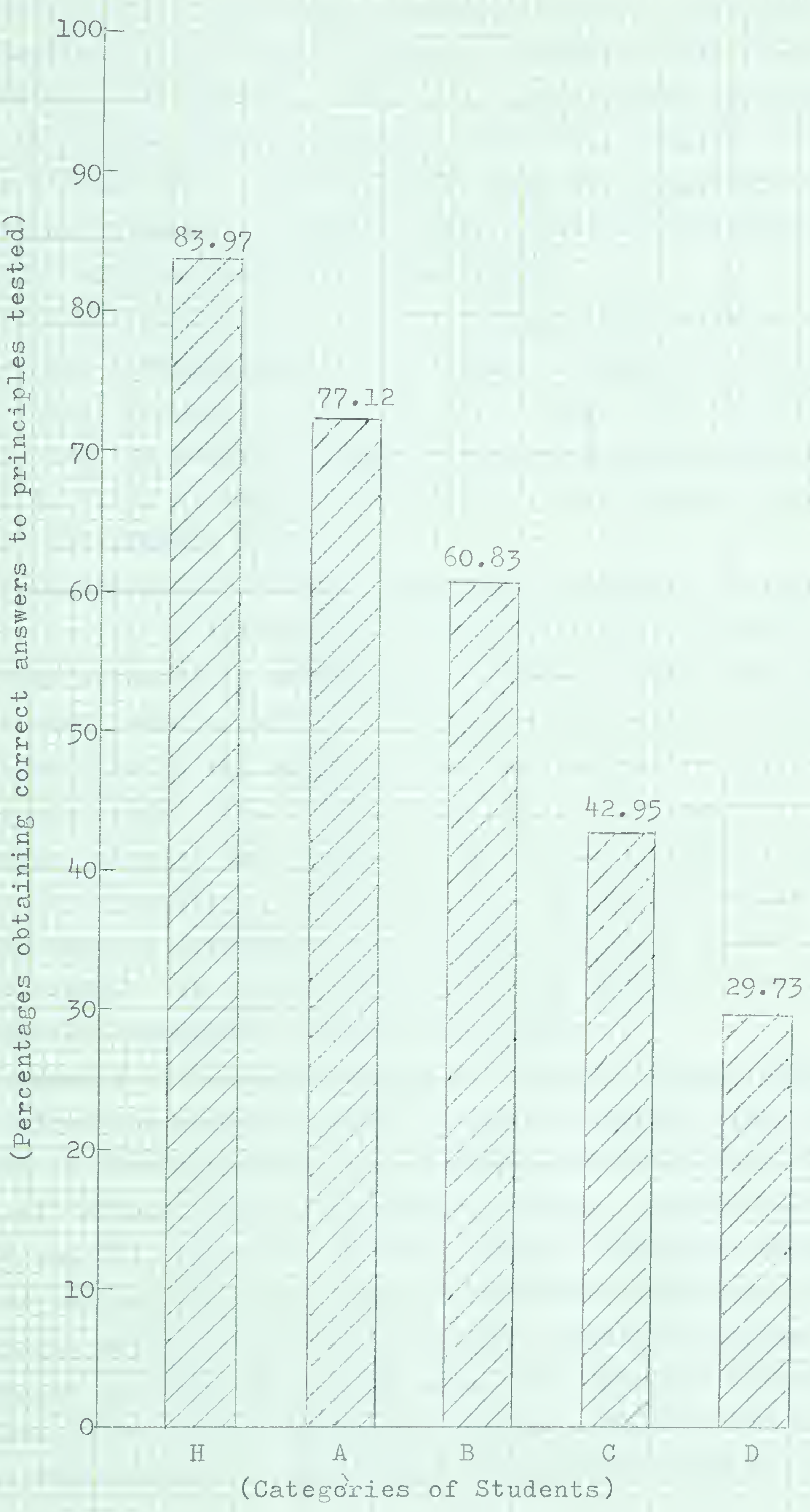

Figure 4. Relative Competence of the Five Categories of Students in Graphic Study

[illegible]

[illegible]

The results of this study indicate that all categories, with the exception of the C and D groups in algebra, made their poorest showing in arithmetic. The H, A, and B groups performed better in algebra than in geometry, while the reverse was true for the C's and D's. It is possible that the relatively high percentages obtained in graphic study might be attributed to the fact that only six principles were tested.

Whereas Figures 1, 2, 3 and 4 indicate the relative competence of the five categories of students in each of the four areas tested, Figures 5, 6, 7, 8, and 9, pages 83, 84, 85, 86, and 87, show the relative competence of each of the five categories, H, A, B, C, and D in the areas of arithmetic, algebra, geometry and graphic study.

The performance of the H category of students is fairly uniform, but it is interesting to note that their poorest results were obtained in arithmetic, an area in which they have had the most years of study. The A group did almost equally well in arithmetic and geometry, but were better in algebra and graphic study. The B group show little difference in arithmetic, algebra and geometry, but are much higher in graphic study. It is worthy of note that the C group were better in geometry than in arithmetic and algebra, and much better in graphic study. The D group performed very poorly in the three major areas, arithmetic, algebra and geometry.

A summary of the percentages of students in each category who obtained the correct answer for each principle might enable teachers to assess quickly the strengths and weaknesses of pupils of various levels of academic ability. Tables CIII, CIV, CV and CVI, pages 88, 90, 92, and 94, show these percentages for each of the four areas of arithmetic, algebra, geometry and graphic study as tested on the 1960 examination paper. The percentages in these tables are taken from the data presented in Tables IX to CII inclusive, but are here rounded off to the nearest whole number to facilitate comparisons among the groups.

The results of this would indicate that all categories, with the exception of the D and E groups in science, made fairly consistent progress in mathematics. The B, C, and E groups performed better in science than in chemistry, while the reverse was true for the D groups. It is possible that the relatively high percentages obtained in general science might be attributed to the fact that all did not take these tests.

[illegible] figures 1, 2, 3 and 4 indicate the relative competence of the two categories of students in each of the four general tests. Figures [illegible], pages [illegible], and [illegible], show the relative competence of each of the five categories, A, B, C, D, and E, on the tests of mathematics, science, chemistry and general science.

The performance of the E category of students is rather uniform, but it is interesting to note that their highest results were obtained in mathematics, as much as [illegible] of the four years of school. The D group did [illegible] well in mathematics and chemistry, [illegible] in general science. The C group [illegible] in mathematics, science, chemistry, [illegible]. It is worthy of note that the C group were better in chemistry than in mathematics and science, and were better in general science. The A group [illegible] in the three major areas, mathematics, science and chemistry.

A summary of the percentiles of students in each category [illegible] might easily be used to [illegible] of each of the four areas of general science. Figures [illegible], pages [illegible], show these percentages for each of the four areas of mathematics, science, chemistry and general science, as tabulated in the last examination period. The percentages in these tables are taken from the data presented in tables [illegible] to [illegible] inclusive, and are here presented in the simplified manner to facilitate comparisons among the groups.

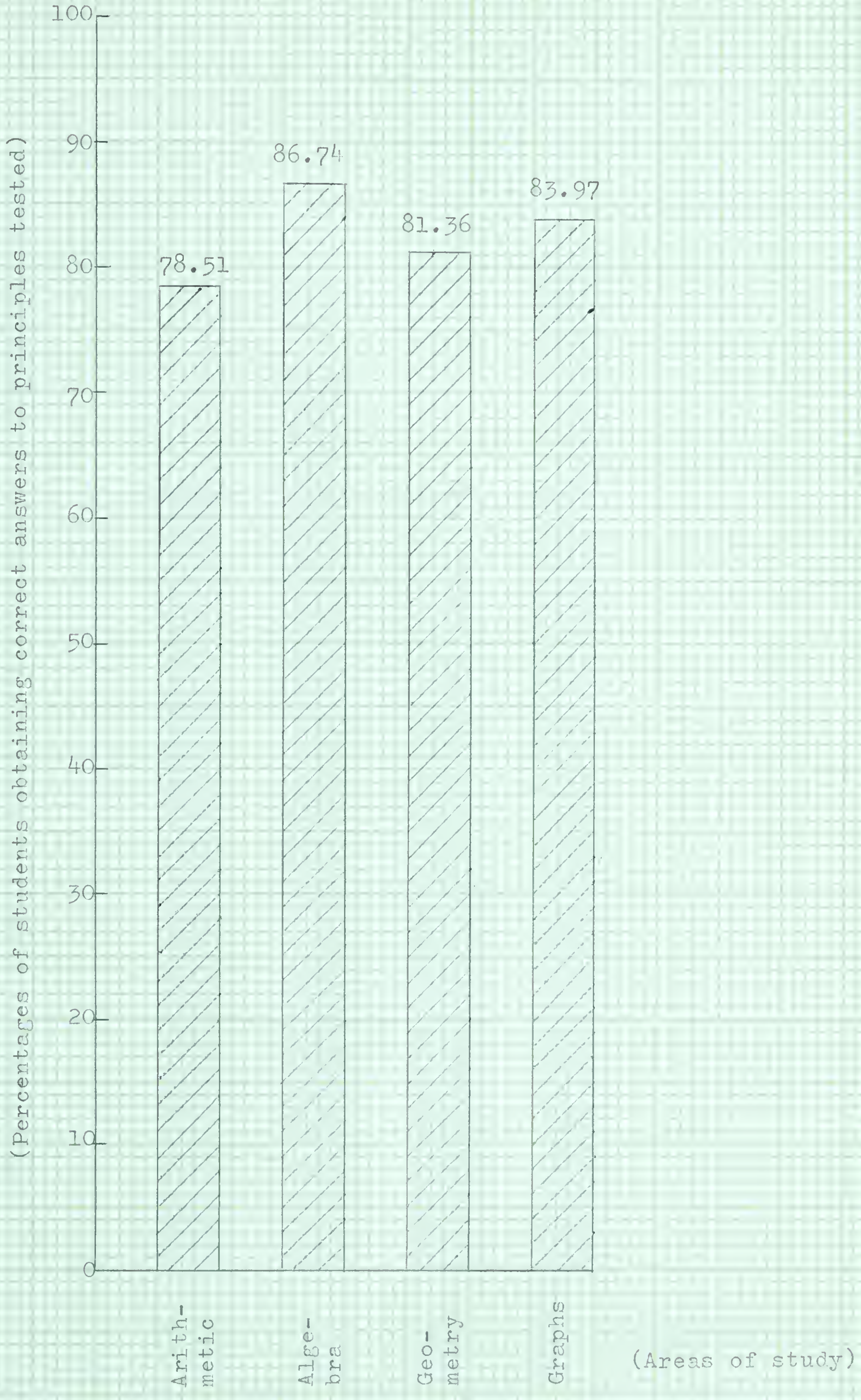

Figure 5. Relative Competence of the H Group of Students in the Four Areas of Study

[illegible]

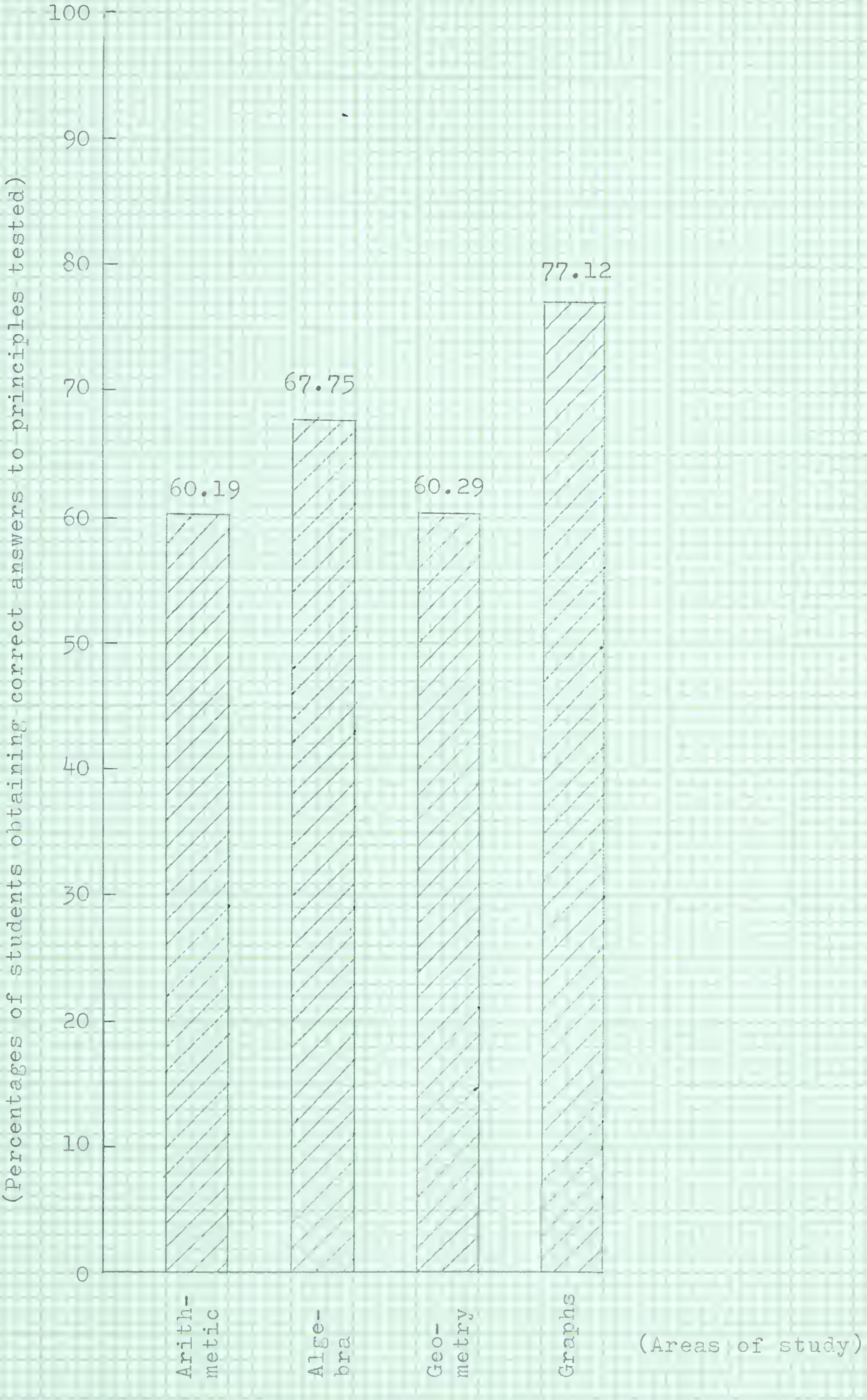

Figure 6. Relative Competence of the A Group of Students in the Four Areas of Study

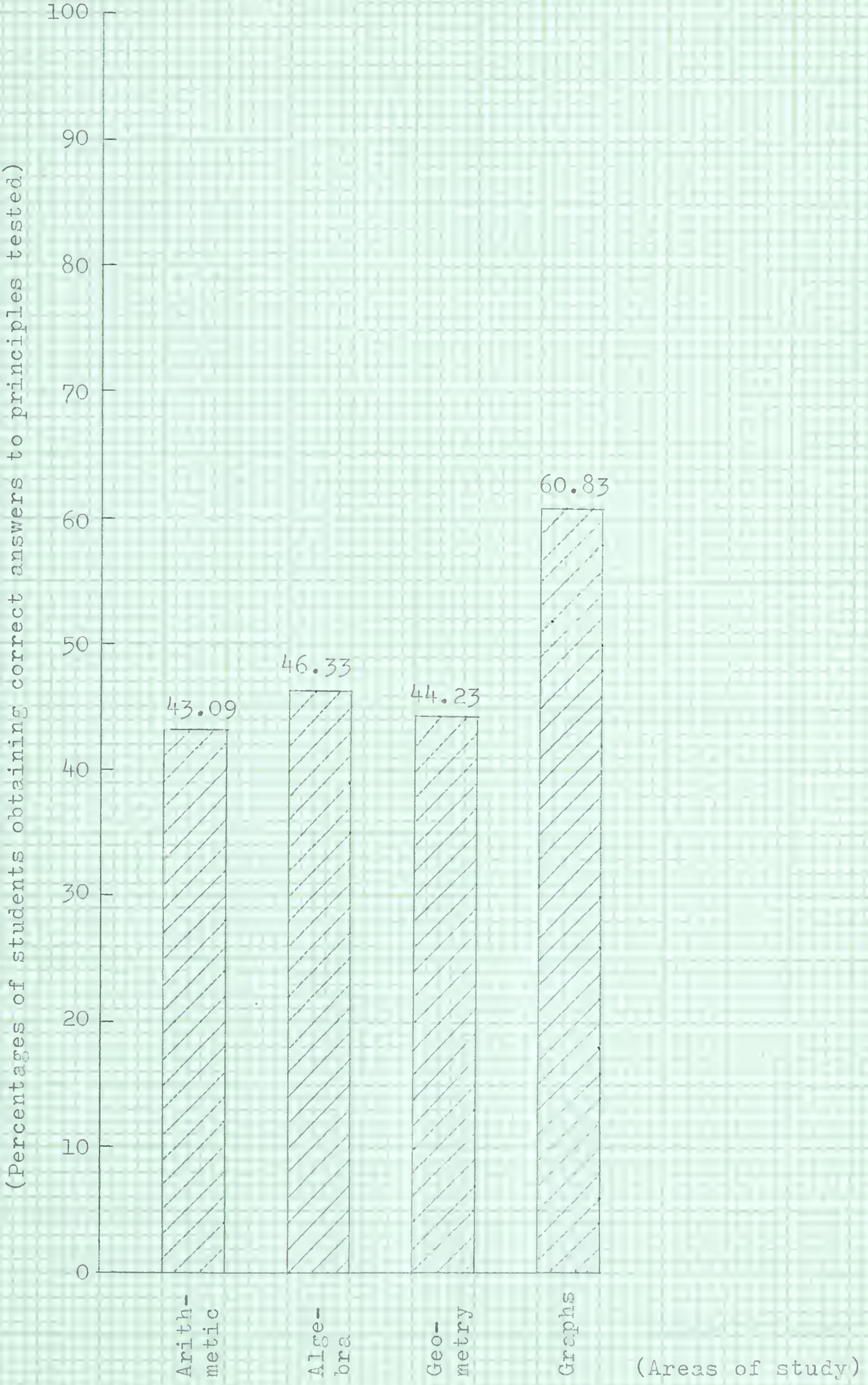

Figure 7. Relative Competence of the B Group of Students in the Four Areas of Study

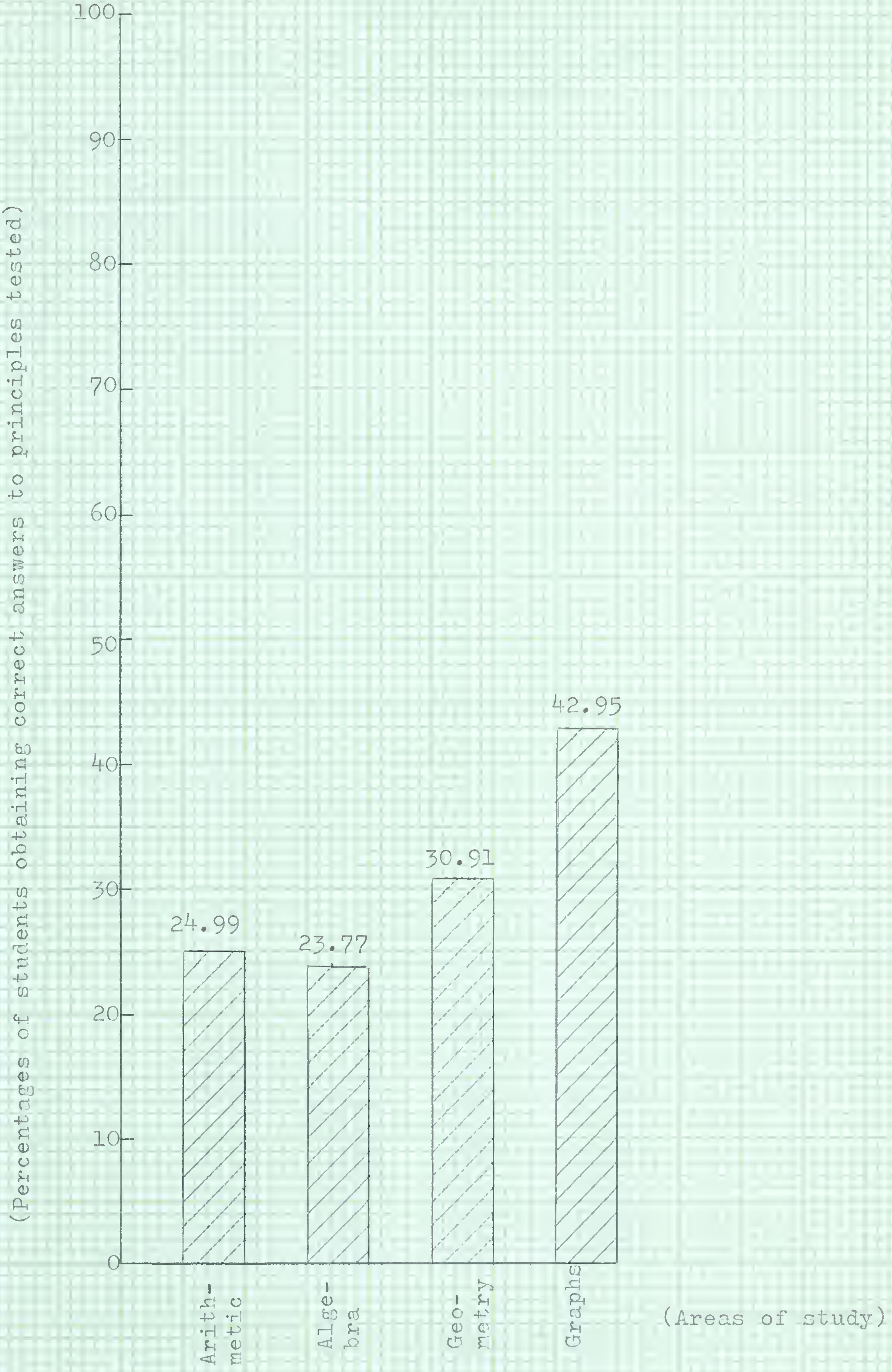

Figure 8. Relative Competence of the C Group of Students in the Four Areas of Study

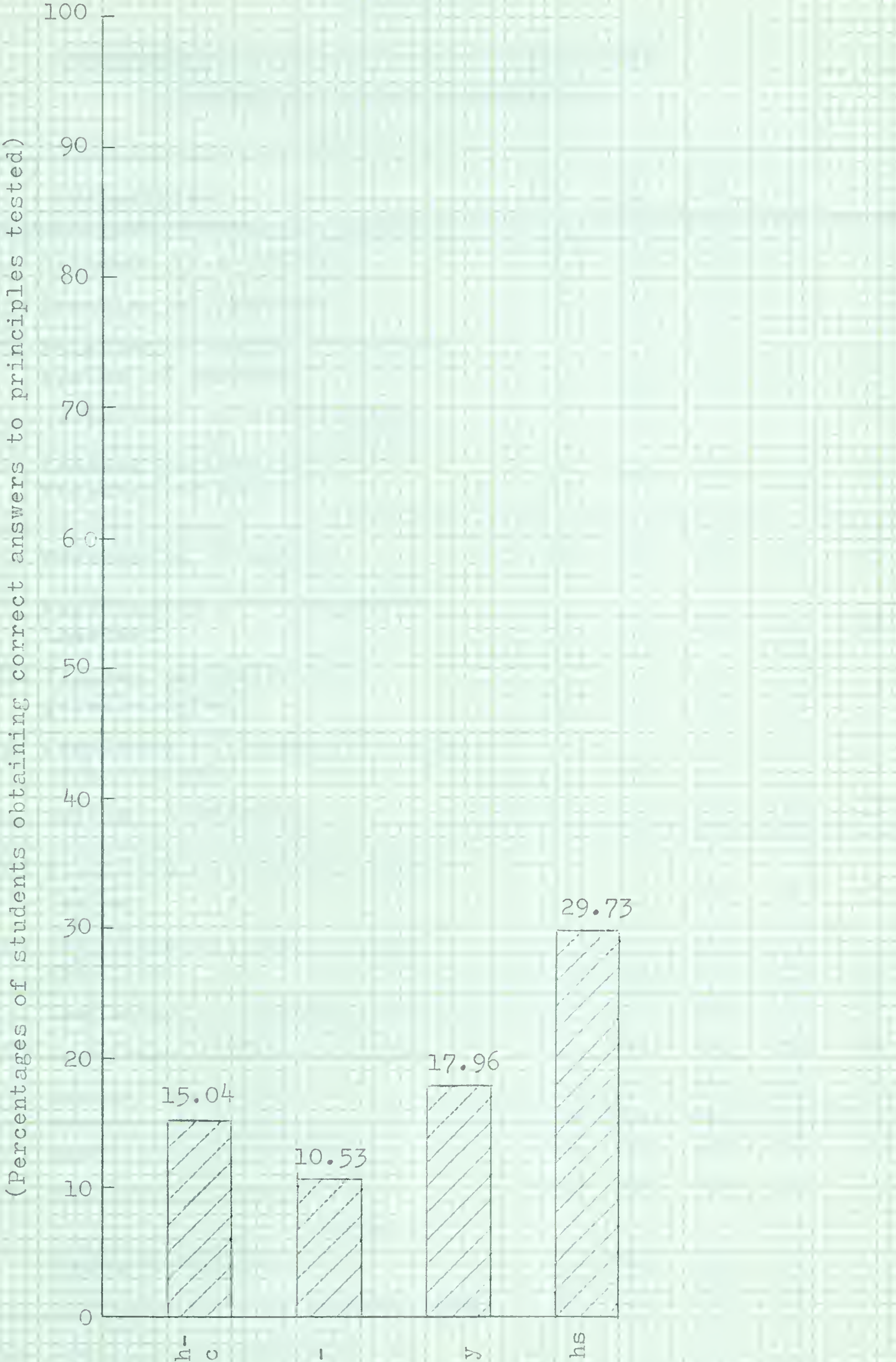

Figure 9. Relative Competence of the D Group of Students in the Four Areas of Study

TABLE CIII

PERCENTAGES OF STUDENTS WHO ANSWERED THE ARITHMETIC PRINCIPLES CORRECTLY

Principle	H	A	B	C	D
1. Division by a decimal;	56	46	25	19	3
2. Rounding off numbers;	56	29	13	12	11
3. Relation of units in another system of measure;	44	33	32	30	22
4. Comparison of area measure;	13	10	14	15	16
5. Finding surface area of rectangular solid;	69	48	36	12	11
6. Conversion of units;	38	11	8	4	3
7. Application of Pythagorean theorem;	95	70	50	42	38
8. Finding perimeter of a parallelogram;	95	60	53	23	22
9. Knowledge of formula for area of a triangle;	97	85	61	41	14
10. Solving a formula;	82	51	33	18	11
11. Knowledge of highest common factor;	82	63	44	13	5
12. Knowledge of lowest common multiple;	56	50	24	8	3
13. Knowledge of composite numbers;	77	57	33	18	19
14. Knowledge of prime factors;	92	96	84	77	82
15. Adding fractions;	95	76	70	38	29
16. Subtracting fractions;	96	78	69	40	32
17. Multiplying fractions;	92	55	47	21	5
18. Converting mixed number to improper fraction;	82	80	59	35	24
19. Simplifying complex fractions;	90	77	56	17	5
20. Changing a fraction to a recurring decimal;	64	60	41	24	11

TABLE CIII (continued)

Principle	H	A	B	C	D
21. Understanding of exponents;	92	76	46	29	5
22. Adding signed numbers;	82	67	48	20	11
23. Multiplying signed numbers;	92	85	73	40	27
24. Dividing signed numbers;	83	60	44	17	12
25. Finding interest;	69	47	28	27	12
26. Finding a percentage of a number;	82	78	50	24	16
27. Finding what per cent one number is of another;	87	89	64	35	22
28. Finding a number when a percentage is given;	97	78	38	19	11
29. Changing mills to per cent;	72	50	32	26	5
30. Finding first discount;	87	76	59	40	16
31. Finding second discount;	85	71	46	23	5
32. Finding reduced price;	88	72	47	24	5
33. Finding cost given per cent gain;	*	9	2	5	0
34. Finding cost given per cent loss;	*	10	0	0	0
35. Determining gain or loss;	*	29	27	18	5
36. Determining amount of gain or loss.	*	14	2	0	0

*Percentages are not given as the number of students who attempted this optional question (3 out of 39) was so small that percentages are not significant.

TABLE CIV

PERCENTAGES OF STUDENTS WHO ANSWERED THE ALGEBRAIC PRINCIPLES CORRECTLY

Principle	H	A	B	C	D
1. Substitution;	85	62	36	16	8
2. Understanding of exponents;	100	95	88	74	35
3. Adding algebraic terms;	90	82	64	30	9
4. Subtracting algebraic terms;	97	83	71	41	22
5. Multiplying algebraic terms;	92	84	67	81	11
6. Dividing algebraic terms;	90	72	62	28	12
7. Knowledge of reciprocal of a fraction;	95	52	35	21	8
8. Knowledge of arithmetic coefficient of a variable;	100	77	58	50	46
9. Multiplying algebraic fractions;	100	74	56	60	54
10. Finding square root of a trinomial;	54	20	8	6	3
11. Changing the subject of a formula;	71	48	18	7	0
12. Application of a formula;	92	62	70	63	49
13. Definition - meaning of a "variable";	90	78	60	32	24
14. Knowledge of formula for area of a parallelogram;	80	52	23	10	11
15. Knowledge of formula for area of a semicircle;	85	74	50	26	3
16. Knowledge of formula for circumference of a semicircle;	31	6	1	0	0
17. Finding relationship of area to radius of a circle;	85	52	35	17	3
18. Knowledge of inverse variation;	87	81	62	46	22
19. Removing parentheses;	82	59	41	12	0
20. Inserting parentheses	97	73	44	8	3

TABLE CIV (continued)

Principle	H	A	B	C	D
21. Writing an algebraic expression;	77	45	19	4	1
22. Writing an algebraic equation;	90	76	54	30	16
23. Multiplying each side of equation by L.C.D.;	83	52	22	5	0
24. Adding term to each side of equation;	94	85	69	40	14
25. Subtracting term from each side of equation;	89	70	43	20	8
26. Dividing each side of equation by same factor;	90	70	41	19	3
27. Interpreting solution of a problem.	56	29	10	0	0

TABLE CV

PERCENTAGES OF STUDENTS WHO ANSWERED THE GEOMETRIC PRINCIPLES CORRECTLY

Principle	H	A	B	C	D
1. Recognition of geometric figures;	97	81	68	53	27
2. Characteristics of geometric figures;	44	23	12	10	5
3. Knowledge of correct spelling;	100	88	76	53	57
4. Naming angles;	83	61	33	28	18
5. Bisecting a given angle;	90	66	61	40	24
6. Construction of an angle equal to another angle;	69	43	31	17	0
7. Bisecting a chord;	94	65	40	29	12
8. Finding the center of a circle;	92	61	50	24	11
9. Drawing a circle;	100	78	56	51	54
10. Constructing an angle of 90°;	92	74	41	31	16
11. Constructing an angle of 45°;	90	84	61	49	38
12. Reading bearings;	44	22	16	9	5
13. Knowledge of number of degrees in a triangle;	87	85	64	54	38
14. Knowledge of isosceles triangle;	87	85	62	54	38
15. Knowledge of equality of base angles of isosceles triangle;	87	83	61	54	38
16. Knowledge of supplement of an angle;	91	84	58	37	15
17. Knowledge of complement of an angle;	97	88	61	32	8
18. Knowledge of vertically opposite angles;	95	81	58	31	18
19. Knowledge of alternate angles;	74	54	38	21	14

TABLE CV (continued)

Principle	H	A	B	C	D
20. Knowledge of corresponding angles;	90	73	53	42	27
21. Knowledge of adjacent angles;	100	82	65	51	35
22. Knowledge of transversals;	97	76	56	37	8
23. Relation of pairs of angles;	60	35	23	12	1
24. Knowledge of proportion of sides of similar triangles;	92	56	23	3	3
25. Knowledge of mode.	64	44	43	27	5

TABLE CVI

PERCENTAGES OF STUDENTS WHO ANSWERED THE GRAPHIC PRINCIPLES CORRECTLY

Principle	H	A	B	C	D
1. Knowledge of type of graph;	100	99	98	95	86
2. Knowledge of character of graph;	51	48	22	17	0
3. Drawing line graph;	86	81	59	33	8
4. Naming graph;	72	62	40	18	17
5. Reading coordinates of point of intersection;	80	60	40	14	3
6. Knowledge of number of degrees in central angle of a circle.	99	94	84	67	38

CHAPTER VI

FINDINGS, CONCLUSIONS AND IMPLICATIONS

This study is an attempt to establish, on the basis of the grade IX Departmental examinations in mathematics written in June, 1960, to what extent the students of that year had acquired the understanding and application of the principles tested. Further, it is an attempt to determine the standings of the five categories of grade IX students in terms of their knowledge of the fundamental principles tested on the examination paper, in contrast to their standings in terms of scaled scores as indicated by the letter gradings issued on their diplomas or statements.

A sample of three hundred eighty-nine papers was used. The papers were drawn from the five categories in the same proportion as the numbers in the standings issued by the Examinations Board.

An analysis of the examination paper was made. For each question, or part question, a similar exercise was located in the text book. In this way it was possible to classify each question as arithmetic, algebra, geometry or graphic representation, according to the chapters listed for each of these areas in the curriculum guide.

A list of the principles required in the solution of all the questions on the examination paper was then made. Altogether, ninety-four principles were tested. The percentages of these ninety-four principles devoted to each of the four areas of arithmetic, algebra, geometry, and graphic study corresponded closely to the percentage of material in the text book for each area.

An item analysis was prepared, as well as a separate frequency distribution for each category, H, A, B, C, and D. Each item was checked according to whether the answer was correct, incorrect, or not attempted. The totals in the frequency distribution were converted into percentages.

Where the same principle occurred more than once on the examination paper, the totals were combined.

Tables were prepared to show, for each item in the analysis, the numbers and percentages of pupils in each category who obtained a correct answer, an incorrect answer, or who did not attempt the question.

Graphs were used to compare first the relative competence of the five categories in each of the four subject areas, and second the relative competence of each category of students in the four subject areas.

Finally, a summary was made showing the percentages of students who had each principle correct. It was felt that this summary would answer as briefly as possible the question, "What do these grade IX students know?"

I. FINDINGS

The Department of Education issues diplomas to grade IX students with letter gradings in each subject, which represent the student's performance in relation to the other candidates in the province. These letter gradings are commonly interpreted as representing students' performance on the departmental examinations. This study attempts to determine whether the achievement of the students who wrote the Departmental examination in mathematics in 1960 justifies the letter gradings issued by the Department of Education.

An H grading is awarded to the top ten per cent of the students in the Province of Alberta. This H grading represents percentage marks ranging from 80 to 100 on scaled scores. The standings for each of the five categories of students were obtained for the areas of arithmetic, algebra, geometry and graphic study by expressing the total of correct principles obtained from the frequency tables as a percentage of the possible total. According to this investigation; the H students answered correctly 78.51 per cent of all

the arithmetic principles tested, 86.74 per cent of the algebraic principles, 81.36 per cent of principles in geometry, and 83.97 per cent of the principles in graphic study. In all areas except arithmetic the H students scored higher than the minimum score of 80 per cent indicated on the diploma.

An A grading, representing a scaled score of from 65 to 79 per cent was given to twenty-five per cent of all the students. It was found that the A students scored 60.19 per cent in the arithmetic section of the test, 67.75 per cent on the algebraic section, 60.29 per cent in the geometric section and 77.12 per cent in the section on graphic study. In algebra and graphic study the A students were above the minimum score of 65 per cent, while in arithmetic and geometry they fell below the minimum.

A B grading, representing a scaled score of from 50 to 64 per cent was given to thirty-five per cent of all students. These students scored 43.09 per cent in arithmetic, 46.33 per cent in algebra, 44.23 per cent in geometry and 60.83 per cent in graphic study. They fell below the minimum score of 50 per cent in all areas except graphic study.

A C grading, representing a scaled score of from 40 to 49 per cent was given to twenty per cent of all students. The C group scored 24.99 per cent in arithmetic, 23.77 per cent in algebra, 30.91 per cent in geometry and 42.95 per cent in graphic study. They fell below the minimum of 40 per cent in all areas except graphic study.

The D group represents the lowest ten per cent of the students. These are the failures. They scored 15.04 per cent in arithmetic, 10.53 per cent in algebra, 17.96 per cent in geometry and 29.73 per cent in graphic study.

An evaluation of pupils' performance in individual test items serves to point out the strengths and weaknesses of the different categories. Such an analysis was made, with the results shown in tabular form in Appendix A. The criterion used was the minimum percentages as shown on the diplomas

issued by the Department of Education. Students were considered satisfactory if they scored the minimum percentage or better for their category in an individual test item, and unsatisfactory if they scored less than the minimum. Since the minimum for the D group is zero, all students in this category scored above the minimum, so their performance is not included in the summaries appearing in Appendix A.

It was found that, in arithmetic, the H students scored 80 per cent or better in 21 out of 32 principles. Four of the principles listed under arithmetic are not included for the H students as these were found in the optional question, number 37, and the number of students who attempted this question (3 out of 39) was so small that the percentages are not significant. The A students scored 65 per cent or better in 16 out of 36 principles in arithmetic, while the B students scored 50 per cent or better in 12 of the 36 principles and the C students scored 40 per cent or better in only 6 out of 36 principles.

In algebra there were 27 principles tested. The H group scored 80 per cent or better in 22 of these principles. The A group scored 65 per cent or better in 15 principles, the B group scored 50 per cent or better in 13 principles, and the C group obtained or exceeded 40 per cent in 10 principles.

In geometry, out of 25 principles tested, the H group scored the minimum or better in 19 principles, the A group in 16 principles, the B group in 14 principles, and the C group in 10 principles.

In graphic study, with 6 principles tested, the minimum or better was reached by the H group in 4 principles, by the A group in 3 principles, by the B group in 3 principles, and by the C group in 2 principles.

The D students are the failures, those whose raw score is equated to a scaled score of less than 40 per cent. Their scores in individual test items exceeded 40 per cent in only seven of the ninety-four items on the examination paper.

One item was in arithmetic, i.e., knowledge of prime factors; three were in algebra--knowledge of the arithmetic coefficient of a variable, multiplying algebraic fractions and application of a formula; two were in geometry--knowledge of correct spelling and drawing a circle; and one was in graphic study--the recognition of the type of graph. In only three items of the entire test paper did their performance exceed that of the C students. These were comparison of area measure, knowledge of composite numbers and knowledge of prime factors.

II. CONCLUSIONS

It would be presumptuous to draw final conclusions with regard to the ability of grade IX students in mathematics on the basis of one examination paper. Since a different paper is used each year, the results of any one investigation do not have the same significance as do the results of a standardized test.

However, the current investigation left the writer with the impression that there is room for improvement in large areas of the field of grade IX mathematics. The performance of the H and A groups measures up fairly closely to the standards indicated on the Departmental diplomas. The same thing cannot be said for the B, C, and D groups except, perhaps, in the area of graphic study.

With respect to these last three groups, the impression received by the investigator was that the students frequently exhibited an attitude of unconcern about their work. This was apparent in the number of questions not attempted, the careless manner of setting down solutions, and the general lack of neatness in written work. Only the H group completed the entire paper. The questions most frequently omitted by the other groups were the optional questions, numbers 36 and 37, and numbers 38 and 39. Both optional questions, 36 and 37, were omitted by four per cent of the A group, by fifteen per cent of the B group, by thirty-one per cent of the C

group and by twenty-two per cent of the D group. Both optional questions, 38 and 39, were omitted by six per cent of the A group, by twenty-one per cent of the B group, by thirty-two per cent of the C group, and by thirty-eight per cent of the D group. It was noticeable that when the students in groups B, C, and D did attempt these problems, many did not carry them through to a complete solution. In many cases only the initial equation was written. In questions 38 and 39, there was considerable evidence of solutions found by inspection rather than by the algebraic method.

The first eighteen questions were of the multiple choice variety. Since few of these were classified as NOT ATTEMPTED, and, in many cases the answer offered indicated a lack of understanding of the question, it seems reasonable to assume that, if the student did not know the answer, he guessed. In these questions, as well as in the paper generally, the amount of rough work shown decreased with the grades. In general, the neatness and precision of the work also decreased with the grades. The poorer students either lacked self-discipline or they failed to realize the significance of the Departmental examination to their senior high school careers.

The unsatisfactory standard of work exhibited by the B, C, and D groups in this investigation poses the same question that has been asked by other investigators--"What can be done to raise the level of achievement in mathematics?" Is the answer to be found only in improved instructional procedures, in more intensive drill on mechanical processes, and in stricter discipline in mathematical routines? Or should we take a second look at the mathematics curriculum and ask ourselves whether our present course is designed to do what it is intended to do? Mathematics, to justify its place in the school curriculum, must contribute to the satisfaction of the needs of the student in the fields of personal living, and social and economic relationships.

A quarter of a century ago, only a small percentage of students went on to complete high school as a requirement for training to enter the professions. The teaching of an academic program of mathematics was justified on the grounds that it was a requirement for university entrance and it can still be justified on that basis. But today the teaching of mathematics must vary with the changing social conditions which bring a changing youth population into secondary schools, and it must recognize the varying ability of the students. The purpose of mathematics today is not to create mathematicians, but to make well-informed citizens.

The maintenance of democracy depends upon the ability of large numbers of people to think clearly about problems essentially mathematical. A mathematics curriculum should be established to include the basic mathematics needed for all citizens. This curriculum would be built by locating and studying concrete problem situations which arise in everyday living. It would involve extensive investigation to define the basic requirements expected of all high school students. Enquiries of business, industry, the army, and training schools for all vocations would establish a foundation for a program of mathematical skill and knowledge necessary for effective citizenship.

A program of this nature could be useful in classifying pupils for the multiple-track program which is now being considered for secondary education. This approach recognizes that a division must be made between academic and non-academic students and that programming must be differentiated to suit the specific needs of each group.

The writer is not suggesting that formal mathematics should not be continued for the academic student. On the contrary, it should be possible to enrich the present courses for those students who are academically inclined. The practice in the past has been to simplify the mathematics course to bring it within reach of the student of

average ability. The establishment of two parallel courses of formal and functional mathematics in the junior and senior high schools should meet the requirements of all students.

In many schools the mathematics program has been weakened by the impression that academic courses are the only respectable ones. One has only to look at the low regard held for Mathematics 11 and 21 in the senior high school program. It must be made clear, not only to pupils but to the general public, that the different mathematics courses designed for multiple-track programming have different goals and experiences for people with different interests. It will be necessary to conduct a campaign of intensive public relations to raise non-academic courses to the prestige presently enjoyed by traditional mathematics. But it is a challenge that teachers must accept in fairness to our youth.

III. IMPLICATIONS

While the current study has attempted to answer specific questions regarding the fund of knowledge acquired by grade IX mathematics students, it has also left unanswered many questions that occurred to the writer during the course of the investigation. First, it must be made clear that any conclusions drawn in this study are founded entirely on the results of one Departmental examination. Therefore, they must be qualified with the observation that this is what the students knew, or did not know, in 1960. In no way is this investigation intended to establish final conclusions regarding the ability of all students who have written, or will continue to write, the grade IX examination. It does seem, though, that a similar comparison of attainments over successive years might be worthwhile to determine to what extent the findings reported here are typical of grade IX students generally. From such an extended investigation it might be possible to establish minimum standards in mathematics for the five categories of grade IX students for the Province of Alberta.

Although no attempt was made in this study to classify results according to sex of pupils, or types of schools attended, the writer was constantly aware of these factors as the papers were being checked, since the name, school and age of each candidate appeared on the machine-scored sheets which were used as answer papers for the questions in Section A of the examination paper. The observation is frequently made that mathematics is a subject for boys and that girls do not do well in it, although Pruett,(9: 505) in an investigation of Indiana schools, found that the opposite was true. It would be interesting to mathematics teachers to find out what the situation is in Alberta.

Cooper (2) found in 1941 that there was little difference in achievement in city, town and rural schools. Since that time, however, vast changes have taken place in the organization of schools, while, at the same time, the province has been passing through a period of acute shortage of well-qualified teachers. It is commonly accepted that students are handicapped by attending small high schools, or schools in outlying areas, but, as far as can be determined, no recent study has been made to substantiate these claims in the field of mathematics. It seems that a study classifying achievement according to the type of school might serve a useful purpose.

Such a study also raises a related problem. How is student attainment related to the experience and qualifications of teachers?

Peak (8: 1574) found that a definite relationship existed. An investigation which answered this question for Alberta would render a distinct service to the cause of education. Further, qualifications of teachers need not be limited to academic degrees. Bernstein (1: 1567) found that problems of education are only partly problems of intellect. They are also problems of the human spirit, the pupils' liking for the subject, the teachers' attitude

toward the pupils and the subject. He found pupil-teacher relationship a major factor in learning arithmetic. Although this was an American study, there is no reason to believe that the personality of the teacher is not a determining factor in Alberta as well.

It has occurred to the writer that a further study might be made of the value of the graph as a learning device in mathematics. It is true that graphic study is included in the grade IX course, but it is possible that greater use could be made of this form of visual presentation which appeals particularly to the less mathematically inclined student.

A final suggestion is offered. Every teacher of mathematics must be concerned with remedial teaching. The first step in preparing a remedial program is the diagnosis of student weaknesses. This study has attempted to locate these weaknesses in one final examination. Diagnostic tests based upon these findings would determine whether the weaknesses are typical of other classes, and if so, a foundation for remedial teaching would be established. If the findings reported here prove to be of any assistance to teachers and counsellors in pointing out the areas in which remedial teaching seems to be warranted, then this investigation will have served a useful purpose.

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APPENDICES

A. Strengths and Weaknesses of the Five Categories of Students

B. Principles Tested in Each of the Questions on the Examination Paper in Mathematics for Grade IX, June, 1960.

C. The Examination Paper

APPENDIX A

STRENGTHS AND WEAKNESSES OF THE FIVE CATEGORIES OF STUDENTS

Tables CVII to CXIV, following, indicate the individual test items in each of the areas of arithmetic, algebra, geometry and graphic study in which the students' performance was:

i) satisfactory;
ii) unsatisfactory.

TABLE CVII

ARITHMETIC--CATEGORIES OF STUDENTS WHOSE PERFORMANCE IN EACH TEST ITEM WAS EQUAL TO, OR BETTER THAN, THE MINIMUM PERCENTAGE

Principles	H Minimum 80%	A Minimum 65%	B Minimum 50%	C Minimum 40%
Application of Pythagorean theorem;	H	A	B	C
Finding perimeter of a parallelogram;	H		B	
Knowledge of formula for area of a triangle;	H	A	B	C
Solving a formula;	H			
Knowledge of highest common factor;	H			
Knowledge of prime factors;	H	A	B	C
Adding fractions;	H	A	B	
Subtracting fractions;	H	A	B	C
Multiplying fractions;	H			
Converting mixed number to improper fraction;	H	A	B	
Simplifying a complex fraction;	H	A	B	
Understanding of exponents;	H	A		
Adding signed numbers;	H	A		
Multiplying signed numbers;	H	A	B	C
Dividing signed numbers;	H			
Finding a percentage of a number;	H	A	B	
Finding what per cent one number is of another;	H	A	B	
Finding a number when a percentage is given;	H	A		
Finding first discount;	H	A	B	C
Finding second discount;	H	A		
Finding reduced price.	H	A		

TABLE CVIII

ARITHMETIC--CATEGORIES OF STUDENTS WHOSE PERFORMANCE IN EACH TEST ITEM WAS LESS THAN THE MINIMUM PERCENTAGE

Principles	H Minimum 80%	A Minimum 65%	B Minimum 50%	C Minimum 40%
Division by a decimal;	H	A	B	C
Rounding off numbers;	H	A	B	C
Relation of units in another system of measure;	H	A	B	C
Comparison of area measure;	H	A	B	C
Finding surface area of rectangular solid;	H	A	B	C
Conversion of units;	H	A	B	C
Finding perimeter of a parallelogram;		A		C
Solving a formula		A	B	C
Knowledge of highest common factor;		A	B	C
Knowledge of lowest common multiple;	H	A	B	C
Knowledge of composite numbers;	H	A	B	C
Adding fractions;				C
Multiplying fractions;		A	B	C
Converting mixed number to improper fraction;				C
Simplifying complex fraction;				C
Changing a fraction to a recurring decimal;	H	A	B	C
Understanding of exponents;			B	C
Adding signed numbers;			B	C
Dividing signed numbers;		A	B	C
Finding interest;	H	A	B	C

TABLE CVIII (continued)

Principles	H Minimum 80%	A Minimum 65%	B Minimum 50%	C Minimum 40%
Finding a percentage of a number;				C
Finding what per cent one number is of another;				C
Finding a number when a percentage is given;			B	C
Changing mills to per cent;	H	A	B	C
Finding second discount;			B	C
Finding reduced price;			B	C
Finding cost given per cent gain;		A	B	C
Finding cost given per cent loss;		A	B	C
Determining gain or loss;		A	B	C
Determining amount of gain or loss.		A	B	C

TABLE CIX

ALGEBRA--CATEGORIES OF STUDENTS WHOSE PERFORMANCE IN EACH TEST ITEM WAS EQUAL TO, OR BETTER THAN, THE MINIMUM PERCENTAGE

Principles	H Minimum 80%	A Minimum 65%	B Minimum 50%	C Minimum 40%
Substitution;	H			
Understanding of exponents;	H	A	B	C
Adding algebraic terms;	H	A	B	
Subtracting algebraic terms;	H	A	B	C
Multiplying algebraic terms;	H	A	B	
Dividing algebraic terms;	H	A	B	
Knowledge of reciprocal of a fraction;	H			
Knowledge of arithmetic coefficient of a variable;	H	A	B	C
Multiplying algebraic fractions;	H	A	B	C
Application of a formula;	H		B	C
Definition - meaning of "variable";	H	A	B	
Knowledge of formula for area of a parallelogram;	H			
Knowledge of formula for area of a semicircle;	H	A	B	
Finding relationship of area to radius of a circle;	H			
Knowledge of inverse variation;	H	A	B	C
Removing parentheses;	H			
Inserting parentheses;	H	A		
Writing an algebraic equation;	H	A	B	
Multiplying each side of equation by L.C.D.;	H			
Adding term to each side of equation;	H	A	B	C

TABLE CIX (continued)

Principles	H Minimum 80%	A Minimum 65%	B Minimum 50%	C Minimum 40%
Subtracting term from each side of equation;	H	A		
Dividing each side of equation by same factor.	H	A		

TABLE CX

ALGEBRA--CATEGORIES OF STUDENTS WHOSE PERFORMANCE ON EACH TEST ITEM WAS LESS THAN THE MINIMUM PERCENTAGE

Principles	H Minimum 80%	A Minimum 65%	B Minimum 50%	C Minimum 40%
Substitution;		A	B	C
Adding algebraic terms;				C
Multiplying algebraic terms;				C
Dividing algebraic terms;				C
Knowledge of a reciprocal of a fraction;		A	B	C
Finding square root of a trinomial;	H	A	B	C
Changing the subject of a formula;	H	A	B	C
Application of a formula;		A		
Definition - meaning of a variable;				C
Knowledge of formula for area of a parallelogram;		A	B	C
Knowledge of formula for area of a semicircle;				C
Knowledge of formula for circumference of a semicircle;	H	A	B	C
Finding relationship of area to radius of a circle;		A	B	C
Removing parentheses;		A	B	C
Inserting parentheses;			B	C
Writing an algebraic expression;	H	A	B	C
Writing an algebraic equation;				C
Multiplying each side of equation by L.C.D.;		A	B	C

TABLE CX (continued)

Principles	H	A	B	C
Subtracting term from each side of equation;			B	C
Dividing each side of equation by same factor;			B	C
Interpreting solution of a problem.	H	A	B	C

TABLE CIX

GEOMETRY--CATEGORIES OF STUDENTS WHOSE PERFORMANCE ON EACH TEST ITEM WAS EQUAL TO, OR BETTER THAN, THE MINIMUM PERCENTAGE

Principles	H Minimum 80%	A Minimum 65%	B Minimum 50%	C Minimum 40%
Recognition of geometric figures;	H	A	B	C
Knowledge of correct spelling;	H	A	B	C
Naming angles;	H			
Bisecting a given angle;	H	A	B	C
Bisecting a chord;	H	A		
Finding the centre of a circle;	H			
Drawing a circle;	H	A	B	C
Constructing an angle of 90°;	H	A		
Constructing an angle of 45°;	H	A	B	C
Knowledge of number of degrees in a triangle;	H	A	B	C
Knowledge of isosceles triangle;	H	A	B	C
Knowledge of equality of base angles of isosceles triangle;	H	A	B	C
Knowledge of supplement of an angle;	H	A	B	
Knowledge of complement of an angle;	H	A	B	
Knowledge of vertically opposite angles;	H	A	B	
Knowledge of corresponding angles;	H	A	B	C
Knowledge of adjacent angles;	H	A	B	C
Knowledge of transversals;	H	A	B	
Knowledge of proportion of sides of similar triangles;	H			

TABLE CXII

GEOMETRY--CATEGORIES OF STUDENTS WHOSE PERFORMANCE ON EACH TEST ITEM WAS LESS THAN THE MINIMUM PERCENTAGE

Principles	H Minimum 80%	A Minimum 65%	B Minimum 50%	C Minimum 40%
Characteristics of geometric figures;	H	A	B	C
Naming angles;		A	B	C
Constructing an angle equal to a given angle;	H	A	B	C
Bisecting a chord;			B	C
Finding the center of a circle;		A	B	C
Constructing an angle of 90°;			B	C
Reading bearings;	H	A	B	C
Knowledge of a supplement of an angle;				C
Knowledge of complement of an angle;				C
Knowledge of vertically opposite angles;				C
Knowledge of alternate angles;	H	A	B	C
Knowledge of transversals;				C
Relation of pairs of angles;	H	A	B	C
Knowledge of proportion of sides of similar triangles;		A	B	C
Knowledge of mode.	H	A	B	C

TABLE CXIII

GRAPHIC STUDY--CATEGORIES OF STUDENTS WHOSE PERFORMANCE ON EACH TEST ITEM WAS EQUAL TO, OR BETTER THAN, THE MINIMUM PERCENTAGE

Principles	H Minimum 80%	A Minimum 65%	B Minimum 50%	C Minimum 40%
Knowledge of type of graph;	H	A	B	C
Drawing line graph;	H	A	B	
Reading co-ordinates of point of intersection;	H			
Knowledge of number of degrees in central angle of a circle.	H	A	B	C

TABLE CXIV

GRAPHIC STUDY--CATEGORIES OF STUDENTS WHOSE PERFORMANCE ON EACH TEST ITEM WAS LESS THAN THE MINIMUM PERCENTAGE

Principles	H Minimum 80%	A Minimum 65%	B Minimum 50%	C Minimum 40%
Knowledge of character of graph;	H	A	B	C
Drawing line graph;				C
Naming graph;	H	A	B	C
Reading co-ordinates of point of intersection.		A	B	C

APPENDIX B

PRINCIPLES TESTED IN EACH OF THE QUESTIONS ON THE EXAMINATION PAPER IN MATHEMATICS FOR GRADE IX, JUNE, 1960

QUESTION

1. This question was deleted because none of the five given answers was correct.
2. Substitution.
3. Adding algebraic terms.
   Dividing algebraic terms.
4. Knowledge of composite numbers.
   Knowledge of prime factors.
5. Adding fractions.
   Subtracting fractions.
   Multiplying fractions.
6. Finding interest.
7. Knowledge of mode.
8. Relation of units in another system of measure.
9. Reading bearings.
10. Comparison of area measure.
11. Finding surface area of rectangular solid.
    Conversion of units.
12. Knowledge of isosceles triangle.
    Knowledge of number of degrees in a triangle.
    Knowledge of equality of base angles of isosceles triangle.
    Knowledge of supplement of an angle.
13. Recognition of geometric figures.
    Knowledge of correct spelling.
14. Substitution.
15. Knowledge of supplement of an angle.
    Knowledge of complement of an angle.
16. Knowledge of inverse variation.
17. Application of Pythagorean theorem.
    Finding perimeter of a parallelogram.
18. Knowledge of reciprocal of a fraction.
    Knowledge of coefficient of x.
    Multiplying algebraic fractions.
19. a) Understanding of exponents.

    b) Conversion of units.

    c) Finding a number when percentage is given.

    d) Dividing algebraic terms.

19. e) Adding algebraic terms.

f) Finding relationship of area to radius of circle.

g) Finding square root of a trinomial.

20. a) Multiplying signed numbers.
Dividing signed numbers.

b) Changing the subject of a formula.

c) Inserting parentheses.

d) Knowledge of formula for area of a triangle.
Solving a formula.

e) Removing parentheses.
Adding algebraic terms.

f) Knowledge of supplement of an angle.
Dividing each side of equation by the same factor.
Knowledge of vertically opposite angles.

g) Division by a decimal.
Rounding off numbers.

21. a) Application of a formula.

b) Definition - knowledge of a variable.

c) 1. Knowledge of type of graph.

2. Knowledge of number of degrees in central angle of a circle.
Finding what percentage one number is of another.

3. Knowledge of number of degrees in central angle of a circle.
Finding a percentage of a number.

22. a) Writing an algebraic expression.

b) Writing an algebraic equation.

c) Writing an algebraic expression.

d) Writing an algebraic equation.

23. Subtracting fractions.
Adding fractions.
Simplifying complex fractions.

24. Knowledge of highest common factor.
Knowledge of lowest common multiple.

25. Changing a fraction to a recurring decimal.

26. Knowledge of relationship of sides of similar triangles.
Multiplying each side of equation by lowest common denominator.
Dividing each side of equation by same factor.

27. a) Substitution.
Adding signed numbers.
Understanding of exponents.

27. b) Adding algebraic terms.

c) Dividing algebraic terms.
Dividing algebraic terms.
Dividing algebraic terms.

d) Subtracting algebraic terms.
Subtracting algebraic terms.
Subtracting algebraic terms.

e) Multiplying algebraic terms.
Multiplying algebraic terms.
Adding algebraic terms.

28. Writing algebraic expression.
Writing algebraic expression.
Writing algebraic expression.
Writing algebraic equation.
Removing parentheses.
Adding like terms.
Subtracting term from each side of equation.
Dividing each side of equation by same factor.
Interpreting solution.

29. Finding first discount.
Finding reduced price.
Finding second discount.
Finding reduced price.

30. a) Writing an algebraic equation.
Converting mixed number to improper fraction.
Multiplying equation by lowest common denominator.
Adding term to each side of equation.
Dividing each side of equation by same factor.

b) Adding algebraic terms.
Subtracting term from each side of equation.
Adding term to each side of equation.
Dividing each side of equation by same factor.
Substitution (checking).
Adding signed numbers (checking).

c) Multiplying equation by lowest common denominator.
Subtracting term from each side of equation.
Subtracting term from each side of equation.
Dividing each side of equation by same factor.
Substitution (checking).
Adding signed numbers (checking).
Dividing signed numbers (checking).

31. a) Characteristics of geometric figures.

b) Characteristics of geometric figures.

c) Characteristics of geometric figures.

d) Characteristics of geometric figures.

32. a) 1. Knowledge of alternate angles.

2. Knowledge of corresponding angles.

32. a) 3. Knowledge of vertically opposite angles.

    4. Knowledge of adjacent angles.

  b) Knowledge of transversals.

  c) 1. Relation of pairs of angles.

    2. Relation of pairs of angles.

33. a) Constructing angle of 90°.
  Constructing angle of 45°.
  Naming an angle.

  b) Bisecting a given angle.
  Constructing an angle equal to another angle.
  Naming an angle.

  c) Bisecting chord.
  Bisecting chord.
  Finding center of a circle.
  Drawing a circle.

34. a) Knowledge of formula for area of a parallelogram.
  Knowledge of formula for area of a semi-circle.

  b) Knowledge of formula for circumference of a semi-circle.

  c) Substitution.
  Solving a formula.
  Rounding off numbers.

35. a) Adding signed numbers.

  b) Drawing a graph.
  Drawing a graph.
  Naming graphs.

  c) 1. Knowledge of character of graphs.

    2. Reading co-ordinates of point of intersection of graphs.

36. a) Changing the subject of a formula.
  Substitution.
  Solving a formula.

  b) Changing the subject of a formula.
  Substitution.
  Solving a formula.

37. Finding cost given per cent gain.
Finding cost given per cent loss.
Determining gain or loss.
Determining amount of gain or loss.

38. Writing an algebraic equation.
Multiplying equation by lowest common denominator.
Adding algebraic terms.
Subtracting term from each side of equation.
Dividing each side of equation by same factor.

39. Writing an algebraic equation.
    Removing parentheses.
    Adding term to each side of equation.
    Subtracting term from each side of equation.
    Dividing each side of equation by same factor.

APPENDIX C

THE EXAMINATION PAPER

CANDIDATE'S NUMBER

(For the use of the Department only)

DEPARTMENT
EDUCATION ALBERTA

HIGH SCHOOL ENTRANCE EXAMINATION BOARD

DEPARTMENTAL EXAMINATIONS, 1960

GRADE IX

MATHEMATICS

Time—2 hours.

Distribute this time to the best advantage. Do not spend too much time on any one question.

Total Possible mark—160.

SECTION A

Section A of this paper contains questions 1 to 18 inclusive. Answers to these questions are to be recorded on the separate answer sheet which will be given to you by the presiding examiner. Each question has five suggested answers, only one of which is correct. Select the correct answer in each case and record your choice on the separate answer sheet. The example below shows you how to do this correctly.

SAMPLE — Answers — Answer Sheet

The product of 7 and 8 is — 1. 78 2. 48 3. 56 4. 72 5. 15

1 2 3 4 5
⁞ ⁞ ▮ ⁞ ⁞

Be sure to mark your answer distinctly, using the electrographic pencil provided. Make each mark heavy and neat. If you wish to change an answer erase it completely then mark the answer of your choice.

SECTION B

Section B of the paper contains questions 19 to 39 inclusive.

When making constructions be sure to leave all construction lines in your diagram. DO NOT ERASE THEM. They indicate to the marker just how the construction was done.

Space for rough work is provided where required.

DO NOT WRITE YOUR NAME ON THIS BOOKLET.

PLACE YOUR NAME AND SCHOOL IN THE SPACE PROVIDED ON THE ANSWER SHEET.

DO NOT FOLD EITHER THE ANSWER SHEET OR THE TEST BOOKLET.

PLACE ANSWER SHEET AND TEST BOOKLET IN THE SAME ENVELOPE. BE SURE TO SEAL THE ENVELOPE.

1
2
3

(For the use of sub-examiners only)

Values
2 marks
each

SECTION A

Be sure to make heavy black lines in the correct places on the answer sheet. Do not waste your time or spend too long on any one question.

1. $\frac{1}{3}\%$ of \$660 is

1. 1. \$6.60 2. \$19.80 3. \$220 4. \$220.00 5. \$0.22

2. If $a = 2$ and $b = 3$, the difference between the numerical values of $a^2 + b^2$ and $(a + b)^2$ is

2. 1. 0 2. 38 3. 13 4. 12 5. 11

3. Divide the sum of $3a^2 - b + 2c$ and $a^2 + 5b - 2c$ by 2.

3. 1. $2a + 2b$ 2. $2a^2 + 3b$ 3. $2a^2 + 2b$ 4. $a^2 - 3b + 2c$ 5. $2a^2 + 2b - 2c$

4. Choose a pair of composite numbers that have no common factors.

4. 1. 21, 12 2. 8, 9 3. 13, 17 4. 30, 2 5. 4, 16

5. Simplify:

$$\left(1\tfrac{1}{2} + \tfrac{3}{4}\right) \left(2\tfrac{1}{9} - 1\tfrac{2}{3}\right)$$

5. 1. $1\frac{1}{2}$ 2. 0 3. 1 4. $5\frac{1}{16}$ 5. $\frac{5}{9}$

FOR ROUGH WORK

(No marks for work in this space.)

6. The interest on x dollars for y months at $z\%$ is

6. 1. $\frac{\$xyz}{1200}$ 2. $\frac{\$xyz}{12}$ 3. $\frac{\$xyz}{100}$
4. $\$xyz$ 5. $\frac{xy}{12z}$

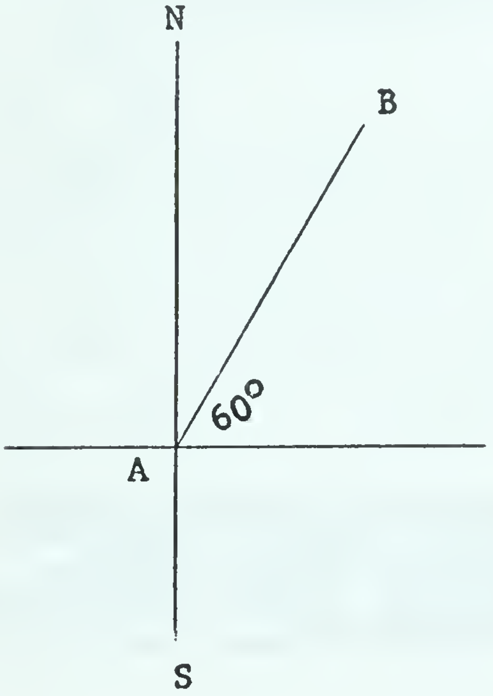
7. The following are the marks of 12 students in mathematics: 90, 76, 45, 60, 59, 60, 59, 80, 75, 59, 72, 61. The mode is

7. 1. 90 2. 45 3. 59
4. 60 5. 66.2

8. The number of litres in one cubic metre is

8. 1. 100 2. 10 3. .1
4. 1000 5. 10,000

9. The bearing of A from B in the diagram below is



9. 1. North 30 degrees East
2. South West
3. West by North
4. South 60 degrees West
5. South 30 degrees West

10. Find the number of square rods in $\frac{1}{4}$ of a quarter section.

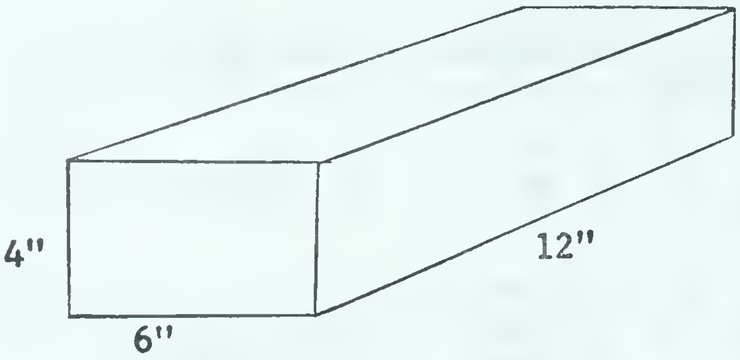
10. 1. 160 2. 6400 3. 40
4. 25600 5. 1600

FOR ROUGH WORK

(No marks for work in this space.)

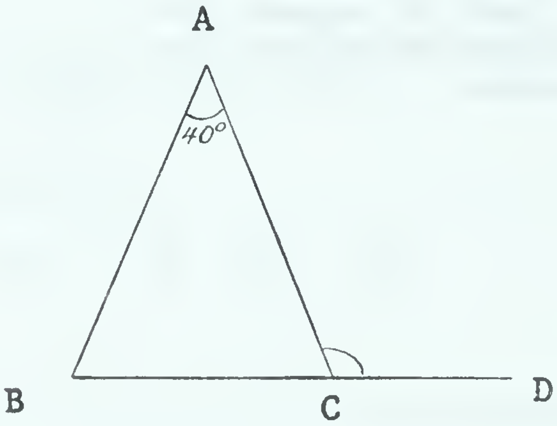
11. The total surface area of this rectangular solid in square feet is

11. 1. 2 2. 288 3. 1
4. 144 5. 24



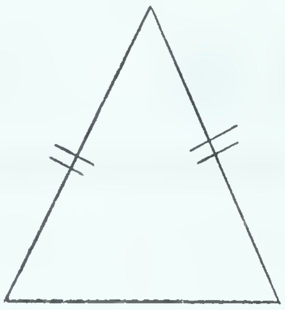
12. If triangle *ABC* has *AB* equal to *AC*, then the number of degrees in angle *ACD* is

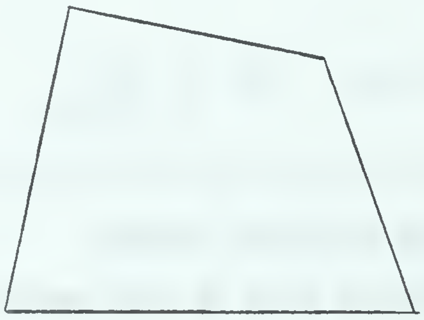
12. 1. 140 degrees 2. 40 degrees
3. 80 degrees 4. 110 degrees
5. 320 degrees



13. Pick out the *correctly spelled* pair of terms which names these two figures.

13.
1. Equilaterial triangle, Polygon
2. Isoseles Triangle, Quadrilateral
3. Isosceles Triangle, Rhombus
4. Isosceles Triangle, Quaderilateral
5. Isosceles Triangle, Quadrilateral





14. Using the formula $C = \frac{5}{9}(F - 32)$ find C when F equals 14.

14. 1. –10 2. $-25\frac{5}{9}$ 3. 10
4. $-24\frac{2}{9}$ 5. $25\frac{5}{9}$

FOR ROUGH WORK

(No marks for work in this space.)

15. The supplement of an angle of 80 degrees is how much greater than the complement of an angle of 70 degrees?

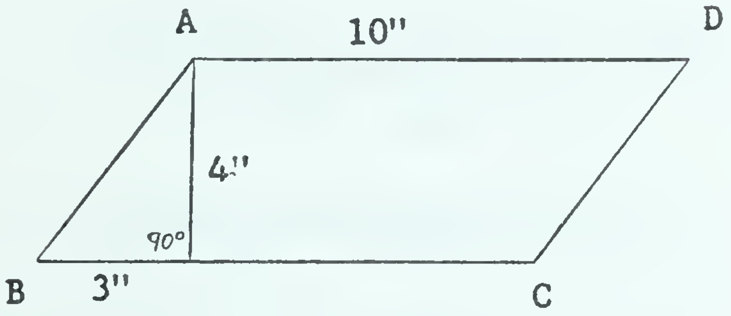
15. 1. 10 degrees 2. 110 degrees
3. 100 degrees 4. 0 degrees
5. 80 degrees

16. $A = \dfrac{120 + x}{4}$

If the denominator of the formula above is doubled, then the value of A is

16. 1. doubled 2. halved
3. quartered 4. tripled
5. unchanged

17. What is the perimeter of the figure *ABCD* if the opposite sides are equal and parallel?



17. 1. 50 in. 2. 30 in. 3. 15 in.
4. 40 in. 5. 34 in.

18. Multiply the reciprocal of $\dfrac{2y}{x}$ by the coefficient of x in the term $6xy$.

18. 1. $3x$ 2. $3x^2$ 3. $\dfrac{3x}{y}$
4. $\dfrac{12y^2}{x}$ 5. $\dfrac{12y}{x}$

FOR ROUGH WORK

(No marks for work in this space.)

Values

SECTION B

7 **19.** Work out the answers to these questions in the space provided for rough work. Place your answers on the dotted lines.

(a) $(0.3)^4 =$ ....

(b) Mow many inches are in one rod? ....

(c) 16.8 is 8% of what number? ....

(d) 77.5 mills is what per cent? ....

(e) Simplify: $6x + \frac{8x^2}{4x} - 5x =$ ....

(f) If the radius of a circle is tripled, the area becomes how many times as great? ....

(g) $\sqrt{a^2 + 2ax + x^2} =$ ....

FOR ROUGH WORK

(No marks for work in this space.)

Values

14 **20.** Work out the answers to the following questions and write each in the space provided.

(a) Divide: (–6) (–3) (2) by (–12) ....

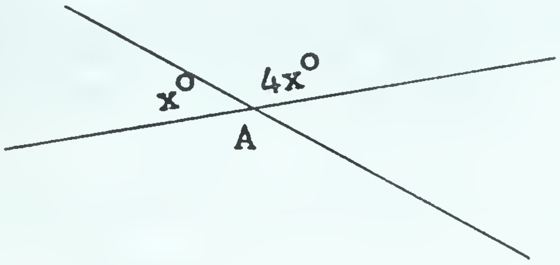
(b) If $d = 16t^2$, then $t =$ ....

(c) Simplify by inserting parentheses:
$4ab^2 - 2a^2b$ ....

(d) The area of a triangle with base 14 inches is 49 sq. inches. Find the height. ....

(e) Remove parentheses and collect the like terms:
$-6(x - 7) + 4(5x - 9)$ ....

(f) Find the number of degrees in the angle marked A.



....

(g) Divide 8,502 by 26.1, assuming that each number is significant to *two* digits only. Round off your answer correctly. ....

FOR ROUGH WORK

(No marks for work in this space.)

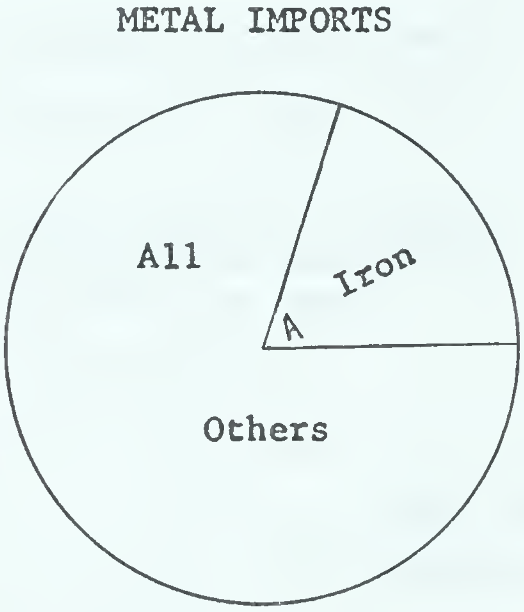
Values

21. Place your answers to these questions in the spaces provided at the right.

1 (a) If you apply the formula $p = rb$ to the statement, 4% of 600 = 24, which number is represented by p? ....

1 (b) In the formula $C = 2\pi r$, which part of $2\pi r$ is the variable? ....

3 (c) The diagram below represents a type of graph which you have studied. Answer the questions asked below.



(1) What is the name of this type of graph?

....

(2) If angle A is 72 degrees what percentage of metal imports is iron?

....

(3) If another sector were constructed representing the 18% of our metal imports that is aluminum ore, what would be the angle of that sector in degrees?

....

4 **22.** Express algebraically, letting x represent the unknown.

(a) An unknown number is doubled and then diminished by 19. ....

(b) When 13 is added to an unknown number, the result is 3 times the unknown number. ....

(c) 12 is added to an unknown number and that sum is divided by 2. ....

(d) Twice the cube of a certain number diminished by 7 equals that number increased by 34. ....

FOR ROUGH WORK

(No marks for work in this space.)

Values

3 **23.** Simplify this complex fraction. Show your work.

$$\frac{\frac{1}{2}-\frac{1}{3}}{1\frac{1}{2}+\frac{1}{8}} =$$

2 **24.** Give the highest common factor and the lowest common multiple of these numbers:

$24x^3y^2z$, $8x^2y^2z^3$

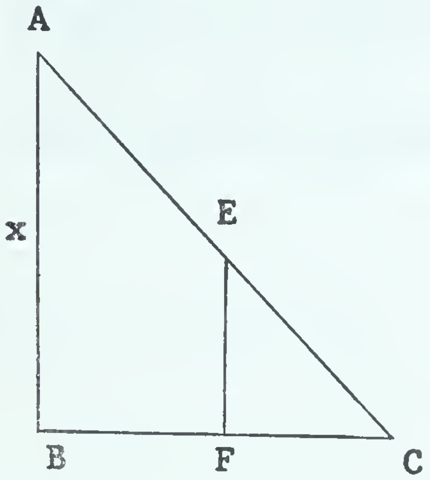
Highest common factor ....

Lowest common multiple ....

2 **25.** Express the fraction $\frac{2}{11}$ correctly as a recurring decimal.

Answer ....

5 **26.** In the figure below, triangles *ABC* and *EFC* are similar. If $BC = 20$ yd., $EF = 12$ yd. and $FC = 8$ yd., find the distance from *A* to *B*. Place your answer in the space provided, but be sure to show your work. In your solution let *AB* equal *x* yd.



Answer $AB =$ ....

FOR ROUGH WORK

(No marks for work in this space.)

Values

27. Perform the required operations in each problem below. Be sure to write your answer in the most acceptable form. Write your answer neatly in the space provided.

3 (a) If $a = 2$, $b = 3$, and $c = 0$, find the value of:

$2a^3 + b^2 - ab^2c$

....

2 (b) Simplify: $7x + 2a^2b + x - 3a^2b - 4x + 2a^2b$

....

3 (c) Divide: $\dfrac{8x^2y - 4xy^2 + 12xy}{-4xy}$

....

3 (d) Subtract:

$$\begin{array}{r} -\,2mn + 4mn^2 + 3r \\ -\,6mn + 8mn^2 - 7r \\ \hline \\ \hline \end{array}$$

....

3 (e) Multiply:

$$\begin{array}{r} 7x - 4y \\ -\,3x - 3y \\ \hline \\ \hline \\ \hline \end{array}$$

....

FOR ROUGH WORK

(No marks for work in this space.)

Values

6 **28.** At a football game, 250 tickets were sold, giving total receipts of $105.00. Some of the tickets were sold at 30¢ and the rest at 50¢. Find the number of 30¢ tickets sold. Solve the problem as suggested.

Let the number of tickets sold at 50¢ each be x

Then the number sold at 30¢ was ....

The receipts from the 50¢ tickets were ....

The receipts from the 30¢ tickets were ....

Equation:

Solution:

The number of 30¢ tickets sold was ....

4 **29.** Read this problem carefully and write the statements you would use in solving it. After each statement you may show the computations involved in that step as a verification or check of the statement. However, you will receive marks for your *statements only.*

Find the selling price of goods which were originally marked at $200.00 if the merchant gave two successive discounts of 20% and 5%.

....

....

....

....

....

FOR ROUGH WORK

(No marks for work in this space.)

Values

3 **30.** (a) Write the equation and solve it. SHOW YOUR WORK.

If an unknown number is multiplied by $5\frac{1}{5}$ and the product is diminished by 3 the result is 23. Find the number.

The number is ....

5 (b) Solve and check: CHECK HERE

$6x + 6 - 2x + x = 7x + 6 - 8$

6 (c) $\frac{x-2}{6} = \frac{2x}{5} + 2$ CHECK HERE

FOR ROUGH WORK

(No marks for work in this space.)

Values

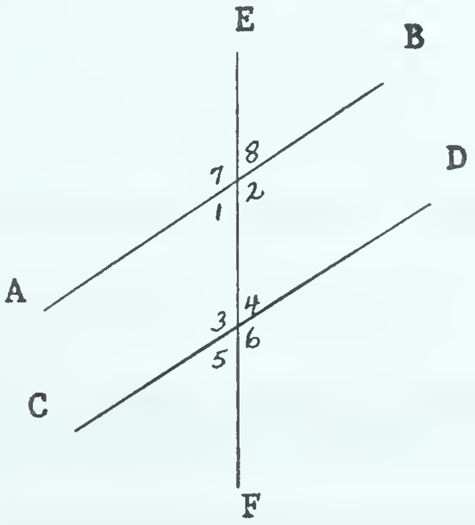
4 **31.** Fill in the table below by selecting the names of two figures from the following list for which each statement in the table is true.

trapezium	parallelogram	quadrilateral
rectangle	rhombus	square

(a) The diagonals are equal.		
(b) The diagonals bisect each other at right angles.		
(c) Each figure has only two axes of symmetry.		
(d) The diagonals bisect the angles through which they pass.		

7 **32.** *EF* is a straight line cutting two straight lines *AB* and *CD* as shown.

(a) Complete the following statements correctly by writing, in each space provided, the number indicating one of the angles.



An angle alternate to angle 4 is ....

An angle corresponding to angle number 7 is ....

An angle vertically opposite to angle number 8 is ....

An angle adjacent to angle 5 is ....

(b) Line *EF* is called ....

(c) Pairs of angles which must be equal in order that the lines *AB* and *CD* will be parallel are called:

(1) ....

(2) ....

FOR ROUGH WORK

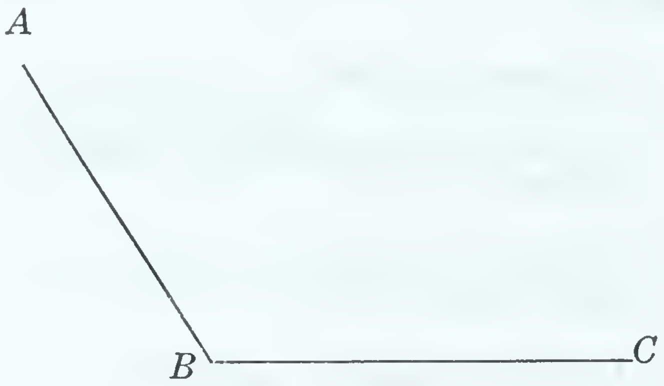
(No marks for work in this space.)

Values

33. Using pencil, ruler and compass only, complete the three constructions asked for below. Be sure to show all construction lines and draw the arcs plainly.

3 (a) At the point *A* on the straight line *AB*, construct an angle of 135 degrees. Do not use a protractor. Letter the angle *CAB*.

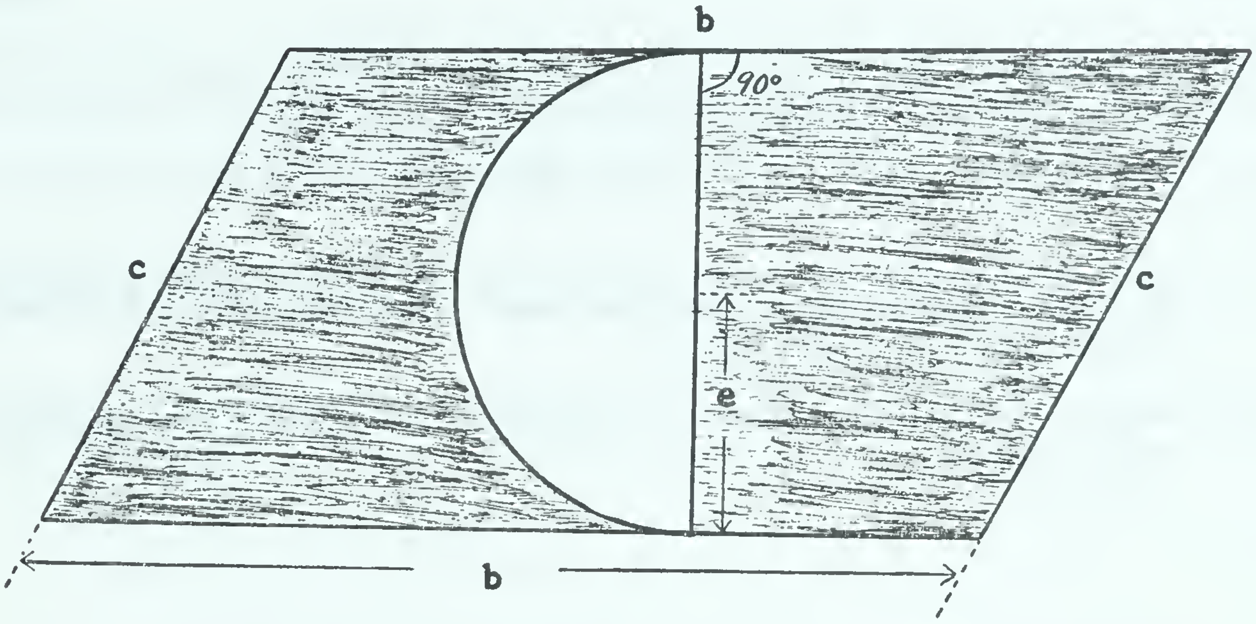
3 (b) At the point *Y* in the line *XY*, construct an angle equal to half the angle *ABC*. Letter the angle *RYX*.



4 (c) Working from the arc of a circle drawn below, find the centre and mark it *C*. Complete the circle.

Values

34. Study the diagram carefully and then answer the questions below. When writing a formula use letters which you find on the diagram.



3 (a) Make up a formula which you would use in finding the area of the *shaded part* of the diagram.

A = ...

3 (b) Make up a formula for the length of the boundary of the *unshaded part.*

B = ...

3 (c) If b equals 15.5 inches and e equals 3.5 inches, find the area of the shaded part to the nearest tenth of a square inch. (Use $\pi = \frac{22}{7}$)

.... sq. in.

FOR ROUGH WORK

(No marks for work in this space.)

Values

2 **35.** (a) Using the formula $y = \frac{x}{2} - 3$, complete the table of values below.

x	0	2	4	6	8	20
y						

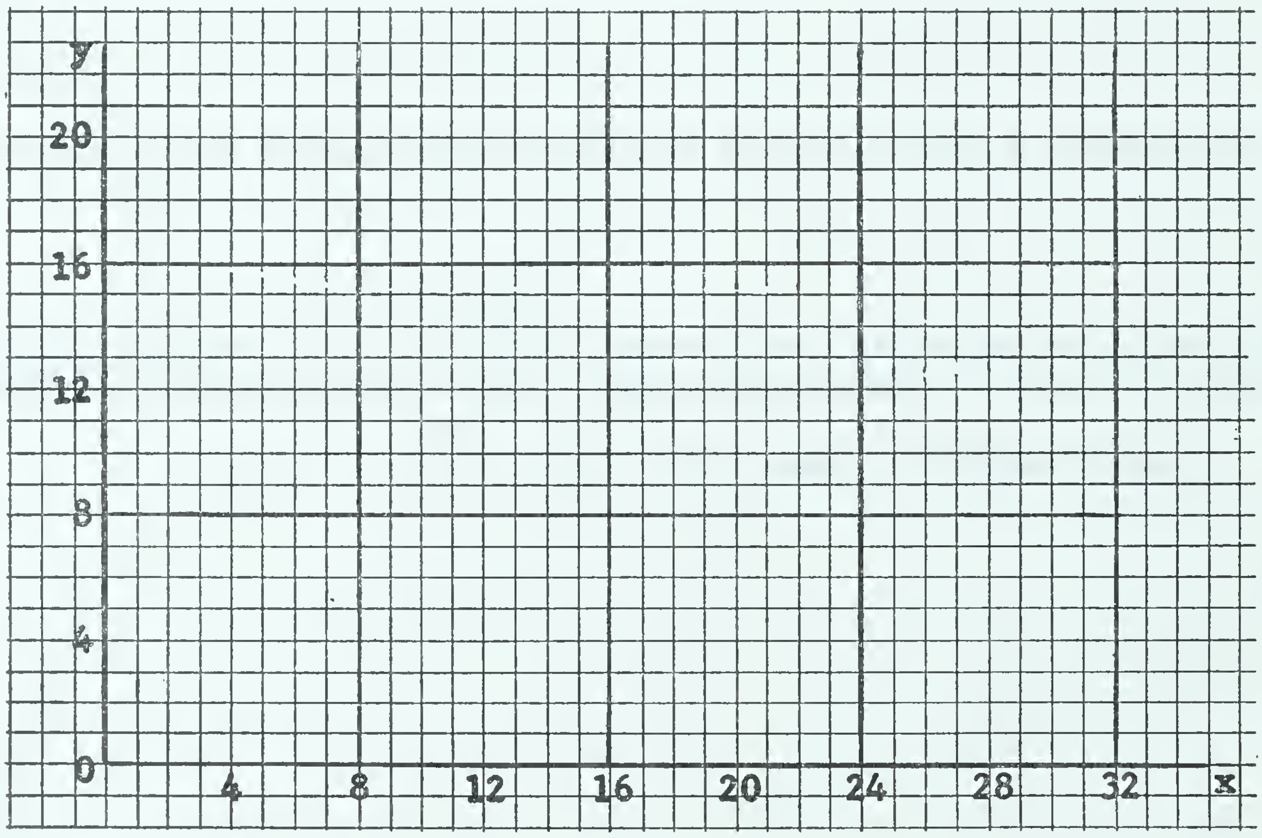
4 (b) Here are two tables of values for x and y. Using these, draw both graphs on the axes of x and y marked below, and label them: Graph A and Graph B. Be sure to answer the questions below the graphs.

FOR GRAPH A

x	4	8	12	16	24	28
y	19	16	13	10	4	1

FOR GRAPH B

x	8	16	20	24	32
y	2	5	7	10	19



1 (c) (1) The character of graph B is ....

1 (2) The values of x and y where the two graph lines cross are: $x =$ .... $y =$ ....

Values

DO EITHER QUESTION 36 OR 37 ON THIS PAGE. DO NOT DO BOTH.

EITHER

6 **36.** The interest formula given in your text is $i = prt$. In each of the following parts of this question write the form of the interest formula needed and use it to solve the problem.

(a) Find the rate per annum at simple interest when $150 amounts to $155 in 8 months.

(b) Find the sum of money which must be invested to yield simple interest of $96.00 at 5% in $1\frac{1}{2}$ years.

OR

6 **37.** Mr. Jones, who was in the cattle business, bought 2 calves at different prices, and then sold them at the auction market for $99.00 each. On one calf he gained 10% of the cost price and on the other he lost 10% of the cost price. Did he gain or lose on the whole transaction, and by how much? (Hint: Find the cost of each.)

He gained or lost? ....

How much? ....

FOR ROUGH WORK

(No marks for work in this space.)

Values

DO EITHER QUESTION 38 OR 39 ON THIS PAGE. DO NOT DO BOTH. IN EITHER CASE YOUR SOLUTION *MUST* BE ALGEBRAIC.

EITHER

6 **38.** One half of a number plus one third of that number plus three quarters of that number exceeds the number by seven. Find the number.

OR

6 **39.** A father is 45 years old and his son is 9. How many years ago was the father 7 times as old as the son?

(No marks for work in this space.)

FOR ROUGH WORK